Environmental and Engineering Programs
Materials Laboratory
Annual Report
2007

Released: April 2008

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Introduction

State Materials Laboratory Mission Statement

"Together we support our customers and enhance construction quality by providing specialized technical expertise, materials testing, and engineering services."

Welcome to our 2007 Annual Report. Our annual report was conceived as a method to convey three messages:

1. How we are measuring our performance, using internal customer performance measures
2. Informing our customers of what we do and what services we offer
3. Provide a road map to where we are headed in the future, especially with the Strategic Directions

We have expanded the Strategic Directions to provide greater detail on this important roadmap to the future. And check out the performance measures: we have driven up performance and driven down costs, especially in field exploration in the Geotechnical Division.

We appreciate any and all feedback.

On behalf of the great crew here at the State Materials Laboratory, I want to thank every customer for using our services and products in 2007; we look forward to serving you again in 2008.

Thanks,
Tom

Thomas E. Baker, P.E.
State Materials Engineer

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Strategic Directions 2007-2009

Construction Materials

Joe DeVol, Bituminous Materials Engineer

Develop a plan to phase out the Hveem mix design system and implement the plan. This should include:
• Time for completion.
• Identify acceptable moisture sensitivity test that does not require use of California kneading compactor.
• Develop plan for laboratory space when Hveem support equipment removed.
This process started in January 2008 but completion delayed until alternative for moisture sensitivity test could be identified and validated.

Additional moisture sensitivity testing underway, data needed to finalize decision on modification to existing procedure. Once procedure modification complete change to specifications likely, implementation would take place after 2008 construction season. Space plan for laboratory completed.

Aggregate Specific Gravity Study. This task has been divided into two separate studies, see task #7 for part 2.
Part one of this study is an evaluation of mechanical methods for the determination of coarse and fine aggregate specific gravity compared to conventional test methods. This study includes:
• Corelok automatic vacuum sealing device and the Thermolyne SSDetect testing system
• AASHTO T84 & T85 aggregate specific gravity test methods.

Initial evaluation of Corelok device and the Thermolyne SSDetect testing system completed in 2005 however the data was inconclusive. Recent work included several aggregate sources with testing performed by qualified technicians. Testing and draft report scheduled for May 2008.

Performance Graded (PG) asphalt binder (Plus Specifications). Where is the nation going and where is WSDOT going?
• What test(s) should be used to verify performance of asphalt modification.
• Work with Pavement Management to establish work plan and identify need for plus specifications.
Trial projects in Eastern Washington in 2006 construction season.

Trial project using an elastic recovery test was completed in the Eastern Region in 2007. The elastic recovery testing specified on this project is completed and a draft report pending. New multiple stress creep recovery (MSCR) testing also performed on samples from candidate project, data being evaluated. Additional projects will be using the elastic recovery test for acceptance in 2008, MSCR test data will also be collected. Data will be analyzed and results reported after 2008 projects completed. Possible implementation of new test and specification in 2009. There is also a new asphalt binder low temperature bond test that uses an Asphalt Binder Cracking Device (ABCD) which we will consider evaluating in the near future.

Examination of N-design: Nationwide research underway to validate the Superpave HMA design levels (compaction tables) for volumetric mix designs. The question is: are current standards giving us the best possible pavement performance?
This study to include:

- Review of WSDOT Equivalent Single Axel Loads (ESAL) and HMA design levels
- Collect production data for comparison to mix design data
- Identify candidate projects to evaluate pavement performance
- Provide recommendations for future Superpave HMA design levels

Since implementation of the Superpave volumetric mix design process in 2004 the Bituminous Materials Section has been collecting test data using both the Hveem stability and Superpave HMA mix design processes on every project paved in the state. Work underway to identify previously constructed projects to use for performance evaluation to compare to mix designs at various levels. This review started in January 2005 and will continue until national standards are changed and/or WSDOT alternative identified.

Implementation of Gyratory Internal Angle Process. Plan being developed to implement internal angle for all WSDOT gyratory compactors. Plan to include:

- Timeline and logistics for accessing compactors in each region.
- Updates to current verification procedure.
- Purchase of additional internal angle calibration devices.
- Training and support to Region staff members.

To be completed by March 2008.

Implementation plan completed, verification procedure updated, DAV-II devices have been purchased, calibration schedule and training plan completed. All gyratory compactors in five of the six regions have been calibrated and set to internal angle, remaining compactors to be calibrated by the end of February 2008.

Performance Prediction Testing (PPT) Study. Produce gyratory compacted specimens from candidate hot mix asphalt (HMA) paving projects to send to Texas Department of Transportation for performance prediction testing. Testing includes:

- Asphalt overlay fatigue testing
- Hamburg wheel rut testing

Study to provide analysis of typical HMA mixes used in Washington State in performance prediction test protocol. On completion of study a report will be written and distributed. This project started in January 2007 and should be complete by December 2008.

Samples collected from three candidate projects and shipped to TxDOT for testing. Data for overlay fatigue testing received, waiting for Hamburg test results.

Aggregate Specific Gravity Study.
Part two of this study is an effort to measure the variabilty of aggregate specific gravity in quary and gravel sources throughout production on select paving projects. This study includes:

- Identification and selection of candidate projects for evaluation
- Scheduling and acquisition of samples
- Testing, analysis and reporting

Study was scheduled for 2007 construction season on four select projects but samples where not acquired as requested on two projects. Testing underway on material received. Additional projects to be identified for 2008, project extended until 2009.

Bob Briggs, Assistant Construction Materials Engineer - Administration

Develop a plan for integrated computer applications for Construction /Materials. Requirements for MATS is currently underway and expect to have an overall plan for future work to be complete by January 2008

Currently the SPMG group is working on ways to intergrate the systems. Eastern Region has developed a system that will be used for field documentation.

Replace RegTec with Mats within 1 year and continue to develop the remainder of Mats. Development is underway and expect to have the first phase of deployment in January 2007 with the complete deployment of MATS by January 2008.

MATS deployed phase 1 in April. The rest of RegTec will be replaced by January 1, 2008

Work on MTP to satisfy people's needs to achieve 100% usage. The plan is to identify the problems in late 2005 and fix the problems in 2006 with 100% usage of the MTP system by January 2007. Due to delays in programming, this project has been extended to April 2008.

The Eastern Region is working on a field documentation system that will require MTP to be used and kept up. With the deployment of MATS, all bid items will come from MTP and test reports will be automatically sent to MTP. A review of the users showed that only 8 PE offices out of 40 were not using MTP. We will ne putting on a training class for MTP, as well as all of our computer programs in 2007/2008.

Acceptance and Approval of Temporary Items

Identify the temporary items that need to have approval and acceptance criteria. These will be identified in the Construction Manual. Expected to be complete in fall of 2008.

Standardized Grout Specifications

This work involves reviewing the different group specifications and come to a standard specification that all will use.

System Approval of guardrail. A committee will be formed to address the DOT requirements by March 2006. Meetings with industry to develop a guardrail suppliers QC plan will occur to implement a plan by January 2007. Due to workload and staffing issues, this task has been extended to fall of 2008.

Fabrication section drafted a QC plan.

Mike Polodna, Structural Materials Testing Engineer

WSU study on the use of low degradation aggregates in concrete.

WSU study on the mitigation strategies for early-age shrinkage cracking in bridge decks.

Masha Wilson, Chemical Materials Manager

Consider X-Ray analysis for steel and cement rather than ICP. This information gathering will start in October 2005 and should be completed in June 2008.

It appears that purchase and use of the X-ray fluorescence spectrometer is not warranted at this time for the following reasons:
Typical XRF (approximately in range of $100,000) will analyze the same elements in hydraulic cements that already are being successfully analyzed by using the Inductively Coupled Plasma Spectrophotometer (ICP) instrumentation recently purchased by the Materials Lab (less than a year ago).

To conduct analysis of a broader sprectrum of chemical elements by using XRF would require purchase of very costly XRF instrumentation (> $200,000)

Chemical elements with atomic number above 9 cannot be analyzed using any of the X-ray fluorescence spectrometer; this would include Nitrogen (N). Currently, we do not have any analytical instructumentation that would be capable of analyzing nitrogen.

Staff training before using XRF equipment will be mandatory to enable staff to understand how to use this instrumentation safely and accurately. Also, designated lab space should be arranged before purchasing XRF instrumentation.

In addition to a wavelength or energy-dispersive spectrometer equipped with a vacuum sample chamber, other materials and products must be purchased to conduct XRF testing using fused disks or pressed powder methods.

Current and anticipated quantities of cement samples submitted to the lab for testing do not warrant a change to our standard procedure. Currently, WSDOT chemists are very much familiar with, and are well trained and qualified in the chemical analysis of hydraulic cement using ICP instrumentation.

Review and modification of the paint specifications. The reviews and modification of specifications should start in January 2006 and be completed in December 2008.

Necessary information and applicable paint specifications are being reviewed to determine what type of paint is no longer being used by WSDOT and identify those paint specifications that should be revised/updated accordingly.

The information gathering started in September 2007. It should be completed in December 2007. The implementation will start as early as January 2008 and be implemented in October 2008.

The series 520 sealing compound tester from Applied Test Systems Inc. has been ordered, received and installed. Training is scheduled to begin in the middle of March 2008 once the vacant position Chemist 3 is filled.

Dwight Carlson, Electrical and Signing Engineer

A review of insulation failures on underground electrical conductors is underway since April 2005 and should be concluded in the next year or so. Complete.

A review of the region / HQ testing program for traffic signal controller assemblies and qualified tester and verified test equipment will be done in the winter of 2005/2006. The review should be complete and a report written by the spring of 2006.

The completion has been moved to second quarter of 2007 in favor of collecting more data. Complete.

Linda Hughes, Quality Systems Manager

Develop videos for all materials testing procedures. November 2005 to September 2007 Overall Project 88% complete; HMA - 100% complete; Aggregate Module; 95% complete; Concrete Module 30% complete; Density Module 10% complete. Added Grout cubes to the list. Filming for Concrete videos is complete, working on editing. Filming for Density Module started.

Develop a plan for implementing Qualified Inspector program. April 2006 to December 2007.

Submitted a plan for qualifying inspectors 45% complete.

Al Gabo, Assistant Construction Materials Engineer - Structural

Improve and streamline Annual Plant Approval document submittal and review process through e-mail and scanning resulting in the finished approved documentation prior to meeting with fabricators for the annual plant approval meeting. July 2007 to June 2009.

Streamlining of Annual Plant Approval process to result in approved documentation prior to annual meetings is 10% complete.

Cross-training of our E-2's in prestress, precast, crosshole sonic logging testing and miscellaneous materials inspection and documentation for uniformity. July 2007 to January 2009.

Geotechnical

Steve Lowell, Chief Engineering Geologist

Develop strategy and implementation plan (including estimated cost, time, and FTE's required) to develop plan to include new and existing geotechnical borings statewide in a GIS database, and begin implementation.
a. Develop strategy and implementation white paper by Dec. 2007.
b. Get funding secured and boring log GIS database creation underway by July 2008.
c. Assigned to: Steve Lowell/Lynn Moses

A GIS specialist has been hired as of Oct. 2006. A detailed implementation strategy white paper is underway, but is yet to be completed. Still in scope of work phase. Anticipate scope of work to be complted by Fall 2008. Actively work on the strategy Fall/Winter 2008/2009

Develop GIS platform useful for geotechnical purposes.
a. Identify target uses of the GIS platform and the layers needed by June 2008
b. Complete GIS platform by Dec. 2008.
c. Assigned to: Steve Lowell/Lynn Moses

A GIS specialist has been hired as of Oct. 2006, and an assistant has also been hired who is focused on project specific implementation as the platform is developed. Several key layers for the platform useful for geotechnical purposes have already been developed. Geotechnical workbench (version 1.0) is near completion. Deployment is planned for March/April 2008.

Engineering geologists to work with regions that have state owned pits and quarries to identify marginal materials and to identify new sources of better materials. Begin with NE corner of the state and aggregates for HMA as pilot project.
a. Complete pilot project by June 2009 and develop plan to advance this effort to other parts of the state.
b. Assigned to: Steve Lowell/Lynn Moses

Pilot project is funded and underway. Data from WSDOT pit and quarry database for Pend Oreille County has been compiled and analyzed. GIS layers have been deployed. Field review or materials sources in study has been conducted. Extensive field work planning for the summer of 2008.

Evaluate potential use of ring nets for rock slope stabilization through experimental features project.
a. Complete experimental features project preliminary report by June 2009.
b. Assigned to: Steve Lowell/Tom Badger

FHWA approvals for experimental features project and waiver of "buy America" requirements have been obtained. Project development is underway. SR 28 Rock Island Slope Protection (w/ring net experimental feature) contract was awarded in December, 2007. Contractor scheduled to start work in March, 2008 with completion scheduled for October, 2008.

Jim Cuthbertson, Chief Foundation Engineer

Implement liquefaction research by the U of W and others through updating the GDM and routine use of of the liquefaction computer program produced as part of research project.
a. Install liquefaction program and train staff in its use by Dec. 2008.
b. Assigned to: Jim Cuthbertson

Program is in final beta testing, and some staff have used it on a trial basis. Final program and associated final report is anticipated by March, 2008. Writing of GDM provisions are underway. Anticipate completion by March, 2008.

Develop expertise and strategies to more accurately assess construction dewatering needs, including geotechnical characterization during design, and development of contract provisions that will provide a more accurate basis for bidding with regard to construction dewatering.
a. Hire licensed hydrogeologist, obtain computer design program(s) (e.g., MODFLOW) plus training, develop GDM guidance, and identify and develop specification changes by Dec. 2008.
b. Assigned to: Jim Cuthbertson/Mark Frye

Concepts and issues have been identified. Presentation on issue conducted as part of 2008 Winter/Construction Conference in February, 2008

Develop strategy with the Bridge Office, and implementation plan, to include assessment of seismic foundation stability problems (primarily liquefaction) as part of Bridge Office seismic retrofit program. This effort, once put into motion, would identify specific bridges that are vulnerable to foundation stability problems, an assessment of the potential risk to the bridge and impact to the public, and an estimate of cost to address the instability so that these needs can be prioritized for programming purposes.
a. Develop strategy and implementation white paper by June 2009.
b. Assigned to: Jim Cuthbertson

A conceptual level strategy has been developed to begin addressing this need. This strategy includes a first cut identification of bridges located in areas mapped as having liquefiable soils. Using GIS, a map that combines bridge locations with areas that are susceptible to liquefaction has been developed, and the overall number of bridges affected has been determined. A more detailed evaluation has been performed for bridges in specific corridors (SR-167, SR-405, SR-5, and SR-90) within currently funded Nickel and TPA projects. A more detailed statewide action strategy will be developed as part of the next highway system plan update - Program management, with help from the Bridge and Structures Office and the Geotechnical Division, will take the lead. Executive level discussions on this issue have taken place, a folio and PowerPoint presentation on the issue has been developed, and presentations to the legislature on the issue to gather support may take place in the 2008 session.

Develop investigation and implementation plan for use of geogrids in pavement base coarse reinforcement and as subgrade reinforcement for pavements.
a. Summarize results from nationwide survey by June 2008.
b. Review research results obtained to date by others, and in consideration of nationwide survey results, determine what is known, and what is not known that needs to be known, developing preliminary design and use policies for geogrids for this application. Do by March 2009.
c. Identify potential test sites where this trial design policy could be tested. Do by June 2009.
d. Assigned to: Jim Cuthbertson

The survey has been completed, but the final report on the survey is yet to be completed due to the heavy workload that has occurred during the past year.

Tony Allen, State Geotechnical Engineer

Develop more detailed chapter for the GDM on foundation design for marine structures, addressing the specific needs of WSF.
a. Complete final draft by June 2008
b. Assigned to: Tony Allen/Jim Cuthbertson
A major update to the GDM was completed by the end of 2006, and another update is underway, targeted for completion in Dec. 2007. The development of new guidance on design of marine structure foundations has been part of this effort but there is still much to do to complete that particular chapter. The chapter on marine structure foundations was updated in 2006 to include special design objectives for marine structure foundations.

Continue to develop geotechnical design procedures in LRFD format for aspects of foundation and wall design that are not currently in LRFD format (soil nail walls, micropiles, noise walls, reinforced slopes, etc.), primarily through continued participation in the AASHTO Bridge Subcommittee and various NCHRP panels, and possibly other research.
a. This will be on-going; updated pile design provisions, new soil nail wall design provisions, and wall provisions are proposed for 2008.
b. Assigned to: Tony Allen

WSDOT will be hosting the mid-year meetings of the AASHTO T-3 and T-15 technical committees in late 2007, where new or updated design provisions were generated/prepared. Updated geotechnical seismic provisions, including liquefaction design, have been completed and are ready for ballot in May 2008. Updated seismic provisions for walls are anticipated for 2009.

Develop long range plan to fully implement MSE wall research (K-Stiffness Method).
a. Complete research reports and publish updated design method in well respected journals – submit journal papers supportig the use of the K-Stiffness Method for high silt content soils by November 2007
b. Work with other states/agencies to identify potential instrumented test walls, including those with lower quality backfill materials to establish accuracy of method
c. Complete RMC research and coordinate with NCHRP study to broaden applicability of research to lower quality backfill materials and also to seismic conditions
d. Prepare agenda item for AASHTO to include new design method in the AASHTO LRFD specifications
e. Assigned to: Tony Allen

Numerous journal papers on the K-Stiffness Method have been published or are in the publication process in a number of international and domestic journals. The most recent work has been done with the assistance of a visiting scholar from Japan, in which the K-Stiffness method was shown to be valid for a series of Japanese walls, broadening the applicability and acceptance of this research. The method has now also been expanded to lower quality backfill materials through the evaluation of Japanese and other full scale wall case histories, and the K-Stiffness method now has a proposed modification to accommodate the cohesion that is usually present in lower quality backfill materials. A lower quality backfill source for use in the RMC full scale walls has been obtained and testing has begun (one full scale RMC wall has been completed and another test well is under construction), so that this adaptation of the K-Stiffness method can be refined. The final experimental features project report for the SR-18 test walls is near completion.

Pavements

Linda Pierce, State Pavement Engineer

Update WSDOT Pavement Policy

The WSDOT Pavement Policy document has not been updated since 2005. Several developments have occurred over this period of time and require update of document (BST project selection, dowel bar type selections, etc.)

Monitor and evaluate (for at least a five year period or until failure) pavement performance and noise characteristics on the three (I-5, Lynnwood, SR-520 and I-405 - construction in 2009) quieter pavement test sections.

Monitoring of Lynnwood began 2006, SR-520 began in 2007 and I-405 Next Generation Diamond Grinding will occur 2008 and OGFC placement in 2009

Refine and update BST project selection (UW study has been completed and specifications have been updated).

BST project selection under development.

Develop dowel bar white paper explaining science and need for use.

Complete - Paper written.

Develop smoothness specification for concrete pavements.

This work has been delayed due to challenges with measuring tined or diamond ground concrete surfaces with laser equipment.

Investigate performance of HMA ¾ inch mixes.

Complete - Paper written.

Jeff Uhlmeyer, Pavement Design Engineer

Evaluate and document design, construction, cost and performance of cold in-place recycling in Washignton State. Develop set of guidelines (for inclusion in WSDOT Pavement Policy) for project selection.

Report under development.

Evaluate and document design, construction, cost and performance of use of rock cap in Washignton State. Develop set of guidelines (for inclusion in WSDOT Pavement Policy) for project selection.

Summarizing available information.

Update pavement performance of Class D and Class D modified HMA.

Report is under review.

Investigate performance issues with NE Washington HMA pavements.

Report is under review.

During the 1990's, WSDOT placed several projects with rubber modified binder. Evaluate the performance of these mixes compared to WSDOT standard HMA performance.

Report is being edited.

David Luhr, Pavement Management Engineer

WSDOT has utilized a HMA smoothness specification over the last several years based on IRI. Are we getting smoother pavements and at what cost?

Projects for evaluation have been identified. Data is currently being reviewed.

The WSPMS has been successfully functioning for over 40 years. However, no consices documentation of the WSPMS exists. This documents will summarize the existing publications as well as describe PMS concepts incorporated into the WSPMS.

Document outline has been completed.

With the intended deployment of the WebWSPMS in 2008/2009, the file building process will need to be documented and developed.

Documentation of current file building process is complete, work has begun on improved computer software for processing files.

Administration

Colleen Reynolds, Information Technology Systems Application Specialist

Identify new technology products and services that will benefit the Materials Laboratory and/or the employees.

Technology fair was held on December 11, 2007.

Develop a plan to attain Materials Laboratory software compliancy, meaning do we have a license for all used software. Establish software used, interview division.

Evaluating software packages to purchase.

Ed Bellinger, Information Technology Systems Specialist

Disaster recovery

This should evolve into a true business continuity plan, which might spawn different projects; Analysis, Solution Design, Implementation, Maintenance. This is still being slowed by OIT's process of trying to unify backup systems.

A customer interview process and form will be created to ease the transition of the new PC, the interview will be given both prior to receiving a new PC and after the new PC has been delivered.

Complete

Disaster Recovery / Business Continuity Implementation

Currently doing DR/BC analysis.

Shannon Huber-Lusk, Information Technology System Specialist

Table of organization for all units with brief description of what people do, FAQs, including what each unit does, who to contact, clean up old reports and data.

Updating pages as data comes in. Rough draft of QSM page is being reviewed.

FAQs, including what each unit does, who to contact, clean up old reports and data.

Getting data from divisions.

Create an internal documentation webpage.

Have been requested to create this page, waiting for content from the documentation employees.

New PC Delivery checklist: Current installation procedure needs to be updated because of new software, interview process etc.

Reviewing the stops for a new PC delivery for precedence and priority. Combining all protocols to create one final agreement.

Kathy Brascher, Information Technology System Specialist

Develop and document requirements and plan for MATS for Phase 3 and 4.

Requirements are complete for Phase 1 and 2 and plan is a living document. Requirements are underway for HMA Mix Design, HMA Reference Design, Soils. Requirements are complete for Aggregate Tests.

Replace RegTec with MATS and continue to develop the remainder of MATS. Development is underway and expect to complete deployment of MATS by January 2008.

Transmittal has been completed. Core process, cylinder and grout tests developed and in production. Looking at phasing in MATS and phasing out RegTec.

Replace Smartware with MATS and continue to develop the remainder of MATS. Development is underway and expect to complete by January 2009.

Aggregate tests requirements complete and development is complete. October deployment planned.

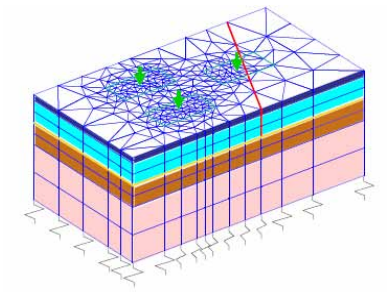
Business Functions

Ongoing Construction/Materials/Pavements Research Projects

Determination of Optimum HMA Density Based on Pavement Performance

With the implementation of the Superpave mix design procedure and the asphalt binder specifications, there is concern that there may be issues related to HMA permeability, which can be offset by ensuring adequate density. Through the data in WSPMS and QA Spec/SAM, this research should determine how HMA density impacts pavement performance, and what level of HMA density is necessary to provide long-lived HMA pavements. In addition, determine how the QA specification has impacted pavement performance over time – the current HMA density specification has not been modified with the implementation of Superpave.

EverStressFE Modifications



EverStressFE is a finite element program for the structural evaluation of HMA pavements. Modification and enhancement of this pavement analysis tool is necessary in order to allow for full implementation and use in the calibration of the Mechanistic-Empirical Pavement Design Guide (MEPDG) procedure. The planned modifications will improve the ease of use, functionality, and the appropriate structural modeling of HMA pavements. This in turn will provide for more accurate prediction of HMA pavement performance, which is essential for the successful calibration, verification and implementation of the MEPDG.

Shrinkage Cracking in Concrete Bridge Decks

Recently, all of the WSDOT bridge decks constructed crack within the first 48 hours after the pour due to concrete shrinkage. The cracks occur in the transverse direction and are typically the full depth of the deck. The cracks provide an avenue for water and chlorides to penetrate the concrete and substantially diminish the deck's service life. This research is needed to determine the cause of the cracking and develop appropriate mitigation strategies.

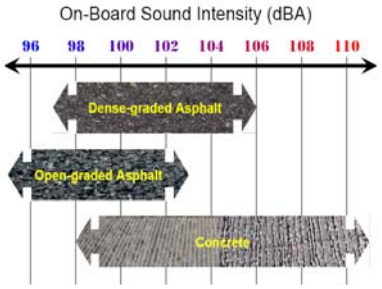
Development of a New Drilled Shaft Acceptance Method

Drilled shafts using the wet method are typically accepted based on successful results of the Cross Sonic Logging test. This method of Quality Assurance testing can only verify the quality of concrete inside the shaft core and does not provide for verification of adequate concrete cover over the shaft rebar cage. There is a lack of reliable test methods to verify the quality of the entire concrete drilled shaft. This research will determine test methods that may be capable of testing for core concrete quality as well as the presence of adequate concrete cover outside the shaft rebar cage and determine the reliability and cost-effectiveness of those test methods.

Concrete Performance Using Low Degradation Aggregate

Generally, as low degradation materials are removed from a quarry, they are typically very hard with low LA wear values, therefore typical material testing cannot determine or predict long-term deterioration. As the low degradation materials are removed from the source and subjected to water, this type of material becomes altered to clay and will not perform as expected. This research will evaluate the long-term performance of concrete when using such aggregates, identify the potential long-term problems with the use of low degradation aggregates in concrete, and recommend test procedures and specifications for future use.

Investigation of Quieter Pavement Performance



This research is intended to evaluate the performance of quieter pavements in the USA and Europe with specific emphasis on California, Arizona, Georgia, Florida, and Texas. The pavement and mix design procedures, construction specifications, construction issues, and life cycles will be summarized and recommendations will be presented on how Washington could potentially use quieter pavements.

De-bonding Cracking in Hot Mix Asphalt Pavements

De-bonding cracking can occur when a HMA surface layer acts independently due to lack of bond with the underlying pavement structure. The fatigue cracks form in the typical bottom-up fashion, but because the surface layer is independent from the underlying pavement, the cracks form in only the surface layer. This research will determine the prevalence of de-bonding cracking and its relationship to tack coat applications and recommend specifications and construction practices to minimize de-bonding cracking.

Best Practices for the Design and Construction of PCCP

This research will provide the most effective and efficient methods of design and construction for use in PCCP design and rehabilitation/reconstruction. The first part of the study focused on stud wear of PCCP, which is a major obstacle in designing and maintaining PCCP over a life span of 50 plus years. The second part will focus on a life cycle assessment of varied options for reconstructing PCCP.

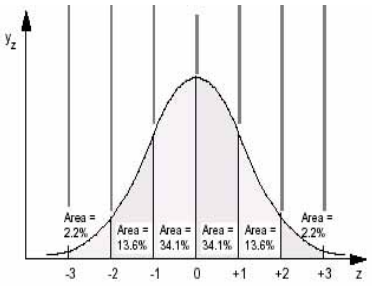
Evaluation of Dowel Bar Retrofit for Long-Term Life

The intended benefit of this research will be an improved understanding of dowel bar retrofit (DBR) pavements and a systematic method for best employing the DBR rehabilitation method. This should result in an improvement of pavement service and money savings. The goal is to better understand the issues surrounding DBR construction and its failure modes, thus allowing WSDOT to: (1) better specify construction standards, (2) specify appropriate rehabilitation applications, and (3) extend the effective pavement life of this type of rehabilitation.

I-5 Corridor Pavement Reconstruction

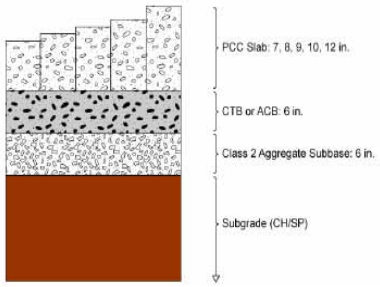
This project will provide long-range planning for the pavement through the I-5 Seattle Corridor. The objectives of this study are three-fold: (1) assess the pavement life of each segment within the 28 mile I-5 urban corridor and determine the estimated terminal distress type and timing, (2) develop improved PCCP performance analysis tools and procedures (EverFE), and (3) initiate a visualization process that can convey the current and future conditions to decision makers and the general public.

Statistical Assessment of QA/QC Data for HMA



Recent trends in the paving industry have resulted in increased contractor involvement in the design, acceptance, and performance of HMA pavements. As a result, questions have arisen about whether contractor process control tests (or QC) should be incorporated into the acceptance and pay factor processes that state highway agencies currently use. To examine this issue, statistical F and t-tests were used to compare QC to QA results. The results of the statistical analysis were analyzed from both a statistical and engineering perspective. Additionally, best practices for both specification and pay factor systems that may attenuate the impact of potential differences between QC and QA results are discussed. In addition to this work, a cursory look at the costs associated with QA and QC will be performed.

CalME Flexible Pavement Design Software Evaluation



This research will provide a demonstration and additional validation of alternative models included in the draft software (CalME) and access to the details of the models and calibration data. Validation of the models and further debugging of the software will be performed by using state DOT project data to predict performance. Documentation of the feedback on the models and software will occur for future use by the state DOTs as they move towards implementation of mechanistic-empirical design methods.

Green Roads

Green Roads is a rating system developed at the University of Washington that distinguishes sustainability-focused new, reconstructed, and rehabilitated roads. It awards credits for approved sustainable choices/practices and can be used to certify projects based on total point value. Green Roads provides (1) a quantitative means to assess the sustainability and environmental stewardship of roads, and (2) a tool for decision-makers that allows them to make informed design and construction decisions regarding sustainability and environmental stewardship of a road. The goal of this research is to develop Green Roads into an implementable standard at the state DOT level.

Effect of Aggregate Gradation on Dynamic Modulus

This work will use data in a NCHRP database that was used to develop models in the MEPDG to statistically evaluate the effect of aggregate gradation on the dynamic modulus of HMA. This information will be used in the implementation of the MEPDG within WSDOT and could also affect HMA mix design procedures depending on the outcome.

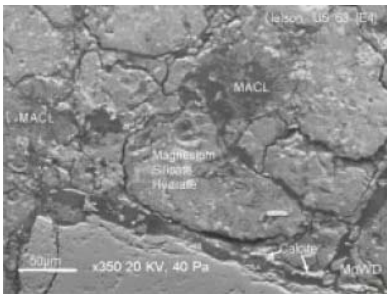
Effect of Chloride-Based Deicers on Reinforced Concrete Pavements and Structures

The focus of this research is the ingress into concrete of chloride-based deicers currently used by WSDOT for winter highway maintenance. Therefore, the emphasis will be placed on investigating the impact of deicer type and salt contamination on the corrosive behavior of rebar/dowel bars in concrete. The liquid deicers that are being tested include: $CaCl_2$, $MgCl_2$, and NaCl (all corrosion-inhibited). The control liquid deicer, against which test results will be compared, is non-inhibited NaCl. Testing is occurring on bridge and pavement sections. The bridge sections include plain rebar in the cracked and non-cracked condition. The pavement sections include dowels with a sawed joint – dowel types are: MMFX, epoxy coated, stainless steel tube with epoxy coated inside, 10 mil epoxy coated, and zinc coated.

Deicer Longevity and Cost-Effectiveness

The objectives of the proposed research are to evaluate the longevity of corrosion inhibitors in storage and on the road as well as their cost-effectiveness, and to establish a reliable measure to quantify the performance of anti-icing and deicing products. This research will allow the transportation agency to determine whether the inclusion of inhibitors into liquid or solid deicers is cost-effective, taking into account: the acceptable deicer corrosivity, reasonable duration of protection expected of inhibitors, and other agency-specific constraints.

Deicer Interaction with Concrete



Some deicing chemicals used for snow and ice control on roads and bridges may cause deterioration of Portland cement concrete. This deterioration is a complex process that involves both physical and chemical alterations in the cement paste and aggregates and is affected by the deicer chemistry, cement ingredients, aggregate reactivity, and environmental conditions. The long-term effect is the potential degradation on the concrete pavements and bridge decks. The goal of this study is to take concrete samples that are currently being exposed to the typical deicer chemicals used in Washington (NaCl, $CaCl_2$, and $MgCl_2$) and perform lab testing (such as x-ray diffraction, scanning electron microscope technology, etc.) to determine if the concrete is deteriorating from exposure to these chemicals.

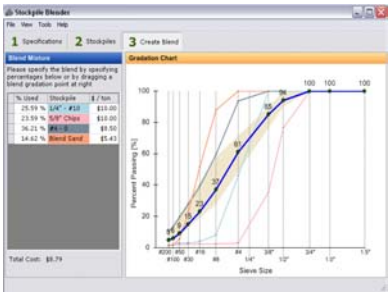
Tire/Pavement Noise Research Consortium

This consortium has been initiated to: provide a forum for states to discuss pavement noise issues, utilize the same measurement techniques to build a tire/pavement noise database, create a synthesis of global practice in regards to utilizing pavement technology for decreasing tire/pavement noise, determine the cost/benefits of using low-noise pavements, and provide guidelines for best practices in measuring and evaluating noise benefits and decreases over the wearing life of the roadway surface.

Western Pavement Preservation Partnership

The WPPP will pool the efforts of the participating agencies to provide a focused look at pavement preservation, and will partner with other regional and national pavement preservation efforts. Pavement preservation issues include pavement policy, specifications, field investigations, applied research, materials, and training.

Pavement Tools Consortium



The Pavement Tools Consortium fosters the continued development and implementation of computer-based paving tools, such as: Pavement Guide, Virtual Superpave Laboratory, Media Library, HMAView, PMSView, Stockpile Blender, XPactor, and EverFE. The major focus of the pavement tools is the enhancement of pavement-related training and construction operations.

State Pavement Technology Consortium (SPTC)

WSDOT is partnering with three other states (California, Minnesota, and Texas) which allows participation in a series of project meetings focused on sharing information, identifying critical issues of mutual interest, developing plans for joint research and testing, and educating transportation professionals on the latest developments in the design, construction, reconstruction and maintenance of highway pavements. The benefits of this arrangement have exceeded millions of dollars since its inception in 1999.

Pavement Reconstruction Scheduling Software

This consortium was formed through the SPTC to develop a software simulation tool which can be used to consider pavement design options along with construction scheduling, resource constraints, traffic management, and user-delays. The CA4PRS software is a construction and scheduling analysis tool to make sound construction project management decisions at each stage of the highway rehabilitation project: planning, design, and construction. CA4PRS estimates how many miles of pavement can be rehabilitated or reconstructed under different traffic closure strategies with given project constraints of: pavement design, lane closure tactics, schedule interfaces, contractor logistics and resources.

Ongoing Geotechnical Research Projects

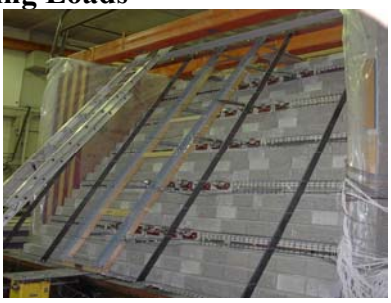
LRFD Procedures for Geotechnical Seismic Design

Develop a framework to determine load and resistance factors that would, accounting for uncertainties in earthquake occurrence and effects, produce designs with reliabilities consistent with those achieved by LRFD procedures for high-probability loading conditions. Development of reliability-based design procedures will allow seismic aspects of design to be consistent with non-seismic aspects, and will allow the reliability of geotechnical elements to be balanced with the reliability of structural elements. They will also allow uniformity across geographic regions – structures in all of the various seismic environments of Washington would be designed for consistent reliability.

Subsurface Drainage for Landslide and Slope Stabilization

Research is needed to identify, collect and develop best practices and guidelines to raise the standards for subsurface drainage design, installation, and maintenance. This research is especially important because subsurface drainage is typically the most cost-effective stabilization measure, often being an order of magnitude less than other commonly employed slope stabilization measures. In addition, the research should explore new applications of existing materials and technologies that can be advantageously applied to subsurface drainage systems for slope stabilization.

Strength and Deformation Analysis of MSE Walls at Working Loads



This work has developed an improved method for internal stability design of MSE retaining walls, the K-Stiffness method. This method appears to produce a more cost-effective design for MSE walls as compared to the AASHTO Simplified Method. The K-Stiffness method has only been developed and validated for high quality sandy backfill soils. The next two phases will extend the K-Stiffness method to 1) marginal quality backfill materials and 2) full-scale field walls that will be monitored for validation. The validation of the K-Stiffness method for marginal quality backfill materials and monitoring full-scale walls is necessary to incorporate this method into the AASHTO LRFD design specifications.

Recently Completed Construction/Materials/Pavements Research Projects

Dynamic Modulus Test – Laboratory Evaluation

A database of dynamic modulus values for typical Superpave mixes widely used in the state of Washington was developed and used to investigate the sensitivity of the dynamic modulus to aggregate gradation. Statistical analysis showed that using different JMF mixes significantly affected the dynamic modulus. This was not the case when modifying the JMF by changing the percent passing #200 by ±2%. With the dynamic modulus as the key input into the MEPDG, Level 1 and Level 3 predictions of rutting, longitudinal cracking, alligator cracking, and IRI were compared with the field performance data. The MEPDG predicted IRI and alligator cracking reasonably well and the predicted rutting of the JMF mixes agreed well with the dynamic modulus trend.

Rapid Pavement Construction Case Studies

This project discusses the implementation, use and experience of using the following items related to rapid pavement construction: CA4PRS, PCCP panel replacement, polymer concrete, and traffic closure windows. CA4PRS was tested in two case studies and has proved capable of providing meaningful scheduling and productivity inputs into early project planning. Panel replacement techniques and polymer concrete construction are reviewed (including contractor interviews) in an effort to document past successes and failures as well as key decision points when making future project decisions. Finally, a review of traffic closure windows for rapid construction is presented.

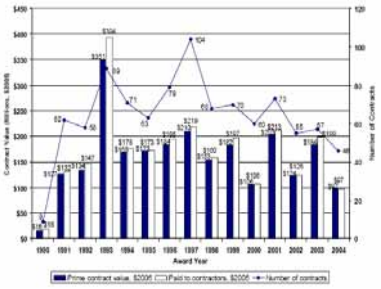
Bituminous Surface Treatment Protocol

The objectives of this research are to (1) improve the criteria on when and where to use bituminous surface treatment (BST) surfacings, (2) gain insight (or criteria) for alternating the application of BST and HMA overlays, and (3) gain insight into how to mitigate noise, roughness, and construction issues with BST resurfacings. The benefits are to enhance the Pavement Preservation Program with improved understanding and use of BSTs.

The first report on improving the criteria is complete. The findings were:

- ADT of up to 2,000: Apply BSTs unless they are specifically exempted.
- ADT of 2,000 to 4,000: Apply a combination of BST and HMA overlays used interchangeably, depending upon pavement condition (exemptions are allowed).
- ADT of greater than 4,000: Apply HMA overlays.

Performance Based Contracting



The objectives of this research were to develop tools that will: (1) monitor the contractor's performance during construction in order to detect any unsatisfactory progress, and (2) improve the time and cost prediction of highway projects in order to reduce time and cost overruns. By using WSDOT historical project data on actual payment estimates and the elapsed working days of each estimate in each project, performance bounds were developed for all projects and for clusters of projects grouped in categories based on quantities of HMA, contract value, project duration, and project miles. Time and cost prediction models were developed on the basis of a number of major variables in pavement projects, including project duration, final contract value, HMA quantity, grading, surfacing, and the number of project highway miles.

Composite Materials for Ferry Wingwall Structures

This research focused on investigating wood plastic composite (WPC) applications in waterfront structures, specifically as a replacement for preservative-treated timber rubbing blocks in wingwall structures. Currently, timber members serve as the contact interface in wingwall structures for ferry vessel berthing in the Washington State Ferry system. Due to environmental concerns with preservative-treated timber and the lifespan of timbers in marine environments, WPC alternatives are being sought. In order to investigate the structural demands of ferries berthing into wingwall structures, specifically the demand on existing timber rubbing blocks as well as potential WPC replacement members, dynamic finite element analyses were performed. Also, new wood-plastic composite formulations and structural capacity assessments were performed.

Dynamic Internal Angle for the Superpave Gyratory Compactor

This study on the angle of gyration for Superpave compactors was done to determine if there is a difference in the bulk specific gravity – and ultimately the volumetric properties – when calibrating the compactor's angle of gyration internally and externally. It was found that 41 percent of the compactors tested were not in specification when using the internal angle to calibrate the compactor. The result was that the measurement of the bulk specific gravity affects the volumetric properties of HMA and therefore can have an affect on the design and acceptance of HMA. Based on the results of this study, WSDOT is working to: (1) evaluate additional gyratory compactors (both WSDOT- and Contractor-owned), (2) make changes to current verification/ calibration procedures, and (3) implement the use of the internal angle of calibration for 2008.

Recently Completed Geotechnical Research Projects

Evaluation of Liquefaction Hazards

This research has been active for over the past six years, with phases 1 and 2 of the project setting the stage for the WSDOT Liquefaction Hazard Evaluation System, a computer program designed to perform multiple sophisticated analyses. The program implements several new methods of analysis and a number of widely used existing methods of analysis. The Manual provides recommendations on how to use each of these analyses, but the program allows the user to combine their results in a manner that allows the attributes of each to be realized.

Performance Measures

Construction Materials Roadway

Bituminous Section Performance Measure

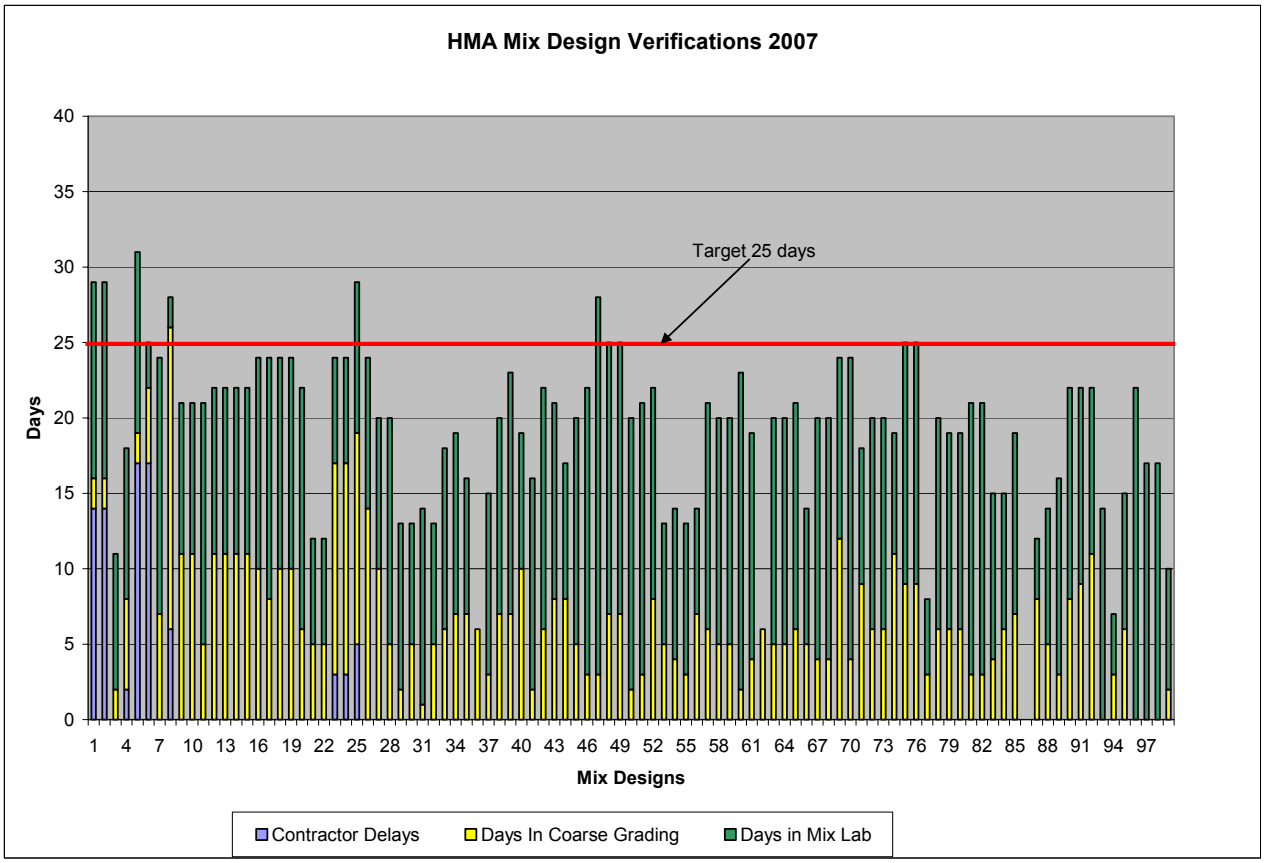
Hot Mix Asphalt Mix Designs Verifications

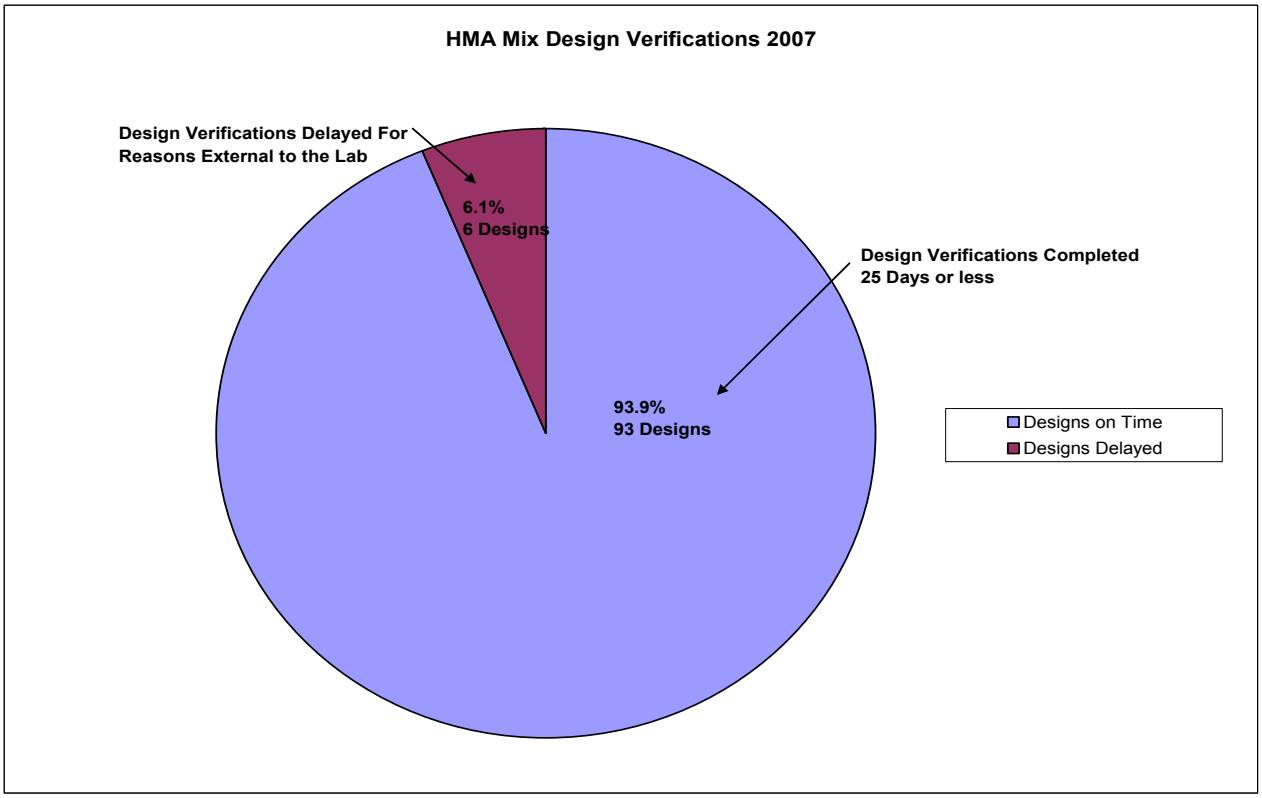
Standard Specification 5.04.3(7)A Mix Designs, states "Prior to the production of Hot Mix Asphalt (HMA), the Contractor shall determine a design aggregate structure and asphalt binder content in accordance with WSDOT Standard Operating Procedure 732. Once the design aggregate structure and asphalt binder content have been determined, the Contractor shall submit the HMA mix design on DOT form 350-042 demonstrating that the design meets the requirements of Sections 9-03.8(2) and 9-03.8(6). A mix design verification report will be provided within 25 calendar days after a mix design submittal has been received at the State Materials Laboratory in Tumwater."

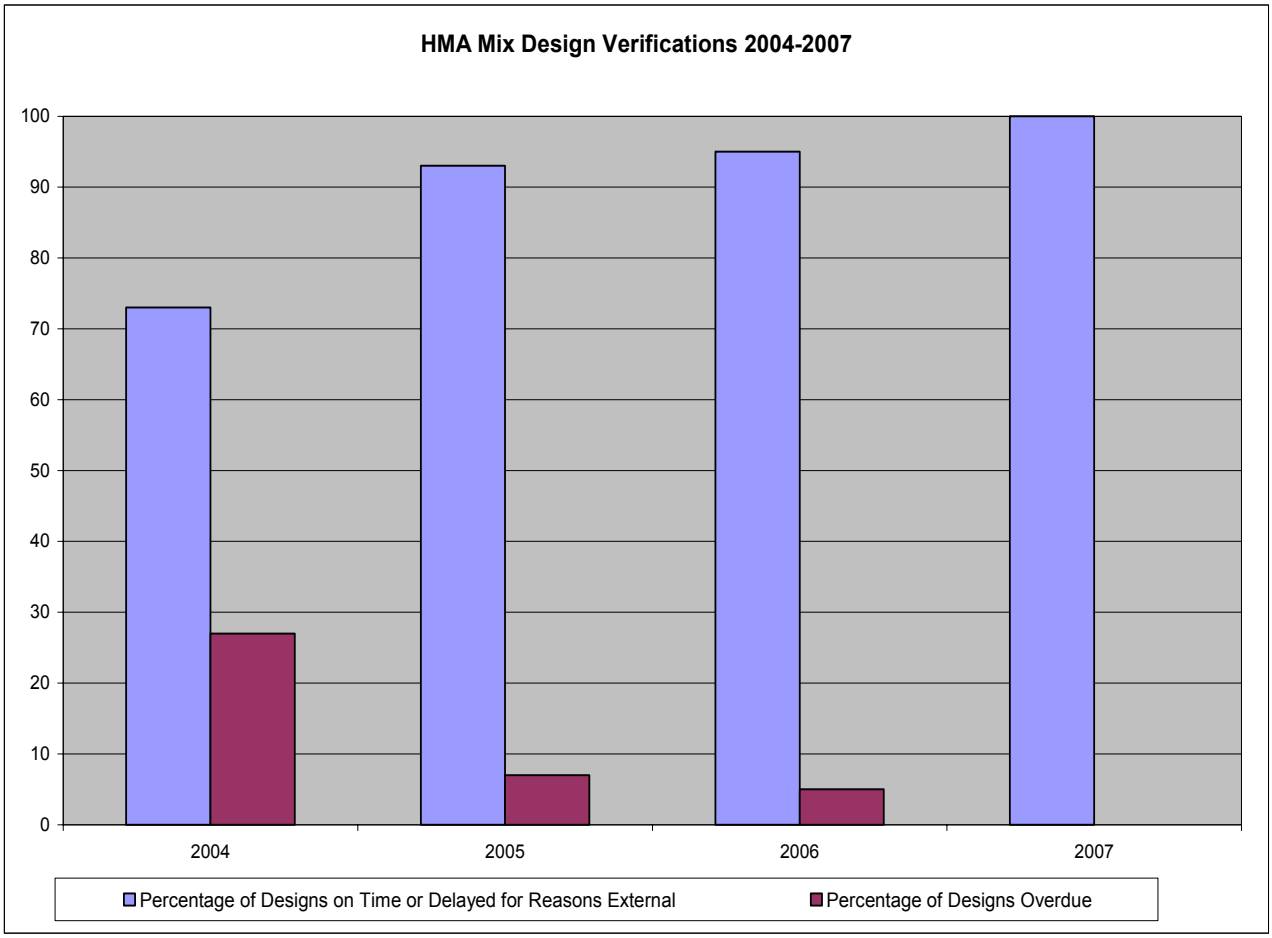
Factors that can affect the 25 day completion schedule:

- Work load in Physical Testing
- Undersized or non-representative samples
- Delays in asphalt binder shipments from suppliers
- Work load in the Bituminous Section
- Special handling of designs
- FTE's
- Equipment and space
- Overtime authorization

In 2007, the Bituminous Section completed 99 HMA mix design verifications. 93 of these design verifications were either completed on or before their due date, and 6 were delayed for reasons external to the Bituminous Section. Two design verifications were cancelled by the Project Engineer during the verification process. The Bituminous Materials Section began measuring HMA mix design verifications in 2004. Performance has improved each year, with 2007 being the first year 100% of all mix design verifications have been completed within 25 calendar days.


HMA Mix Design Verifications 2007
Target 25 days
Days
Mix Designs
Contractor Delays
Days In Coarse Grading
Days in Mix Lab


HMA Mix Design Verifications 2007
Design Verifications Delayed For Reasons External to the Lab
6.1%
6 Designs
Design Verifications Completed 25 Days or less
93.9%
93 Designs
Designs on Time
Designs Delayed

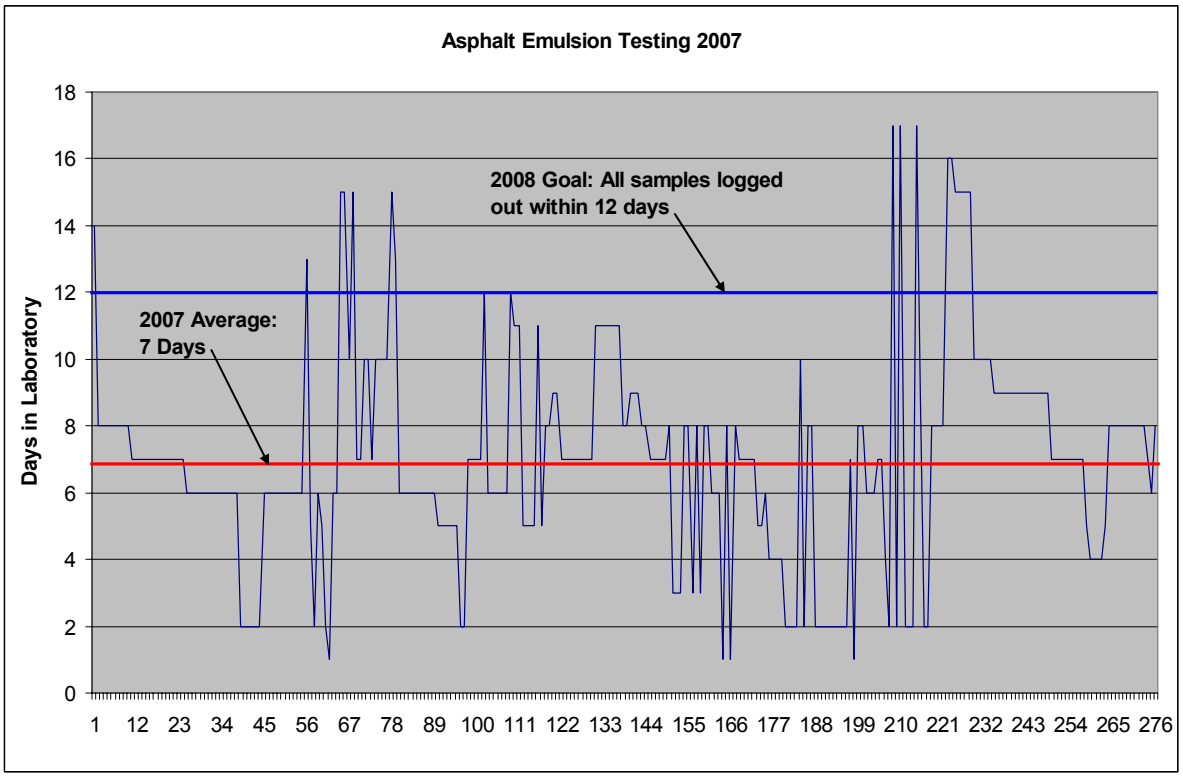

HMA Mix Design Verifications 2004-2007
100
90
80
70
60
50
40
30
20
10
0
2004
2005
2006
2007
Percentage of Designs on Time or Delayed for Reasons External
Percentage of Designs Overdue

Asphalt Emulsion Testing

The WSDOT Construction Manual section 9-5.7 "Acceptance Sample and Testing Frequency Guide" states that Asphalt Emulsions shall be sampled from every other shipment to the project. Asphalt Emulsions used exclusively for tack coat (such as STE-1 and CSS-1) do not require sampling or testing.

The first Asphalt Emulsion sample taken for each day of production, per contract, receives a complete battery of tests per Standard Specification 9-02.1(6), all other samples taken each day will be tested for viscosity only.

The chart indicates the time for all emulsion samples tested in 2007. Average time to report out an emulsion sample is 7 days.



The 2008 Bituminous Materials Section goal for testing Asphalt Emulsions is to have all samples logged out within 12 days. To achieve this goal the Liquid Asphalt Laboratory may utilize additional days and overtime to ensure that testing begins on all emulsion samples within 5 days of receipt.

HMA Mix Design Conformation Samples 2007

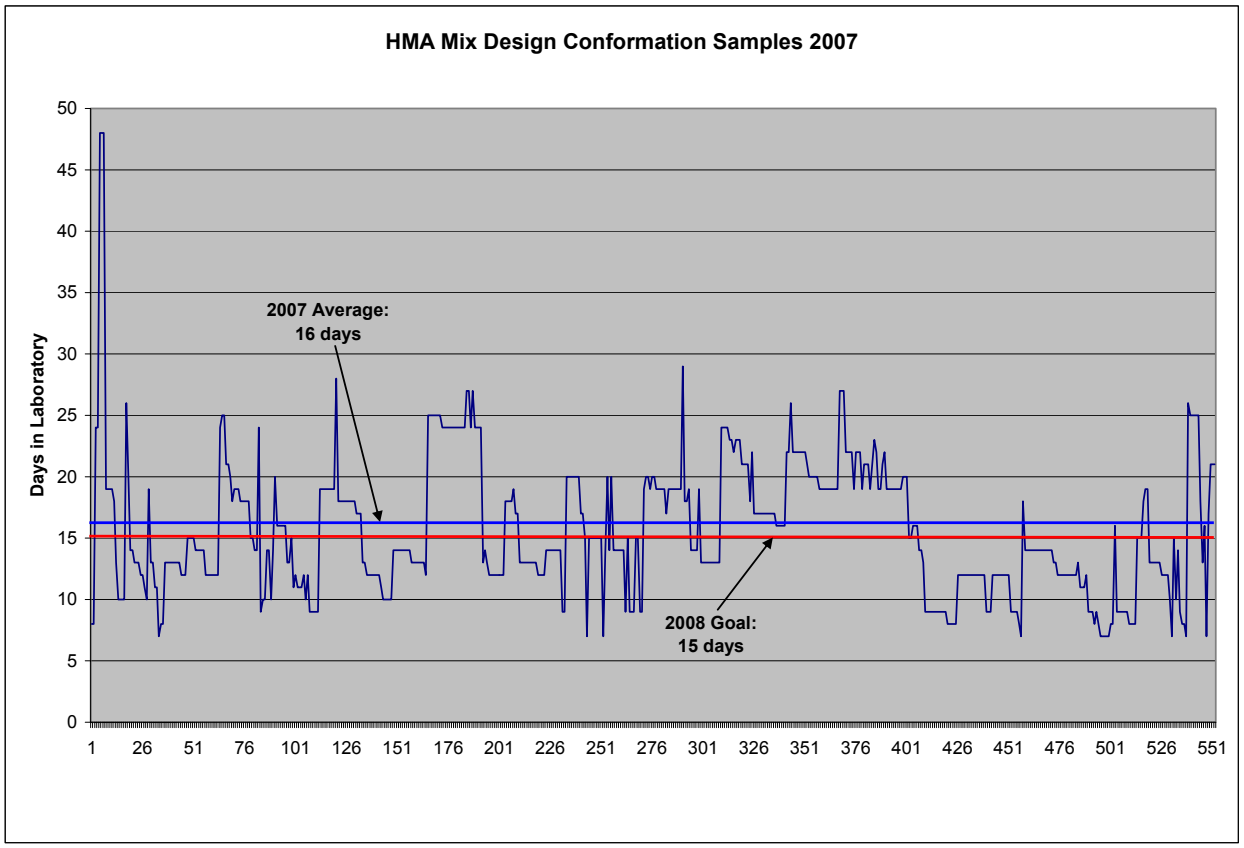
In 2007, the Bituminous Materials Section began measuring the timeliness for completion of HMA Mix Design Conformation Samples for the first time. Mix design conformation samples are actual split samples taken during production and tested for comparison to original mix design properties. For all projects, conformation samples are taken one per day from the first five days of production for each plant and one sample every fifth day of production thereafter. This production data can also be used to determine if a mix design is acceptable for use on additional paving projects. The Bituminous Materials Section occasionally tests challenge samples and/or assist in the troubleshooting of problematic HMA issues outside the normal conformation sample testing schedule. Although conformation samples do not have a formal timeline for completion, the 2007 construction season was used to measure and monitor the completion of samples to establish a baseline for subsequent years.

The basis for this Performance Measure is quite simple. Each sample was measured in days from the time it was received at the Headquarters Materials Laboratory until it was tested and logged out by the Bituminous Materials Section.

Factors that can affect a timely completion schedule:

- Workload in the Bituminous Materials Section
- FTE's
- Equipment and space
- Overtime authorization

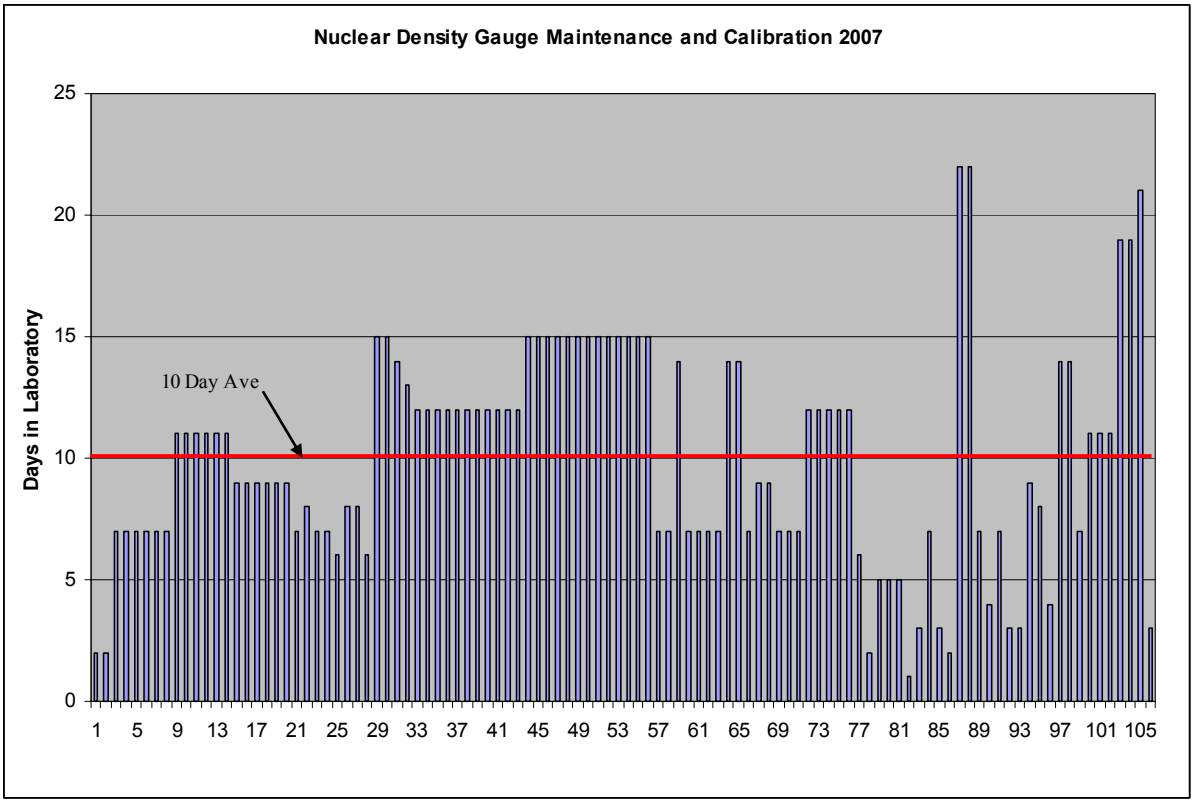
In 2007, the Bituminous Materials Section tested 581 HMA mix design conformation samples. The average time of completion for these samples was 16 calendar days. The Bituminous Materials Section has established a goal of 15 calendar days for the 2008 construction season.



Nuclear Density Gauge Maintenance and Calibration 2007

The Bituminous Materials Section, Nuclear Electronics Laboratory, performs the annual maintenance, calibration and repair of all the nuclear density gauges owned by WSDOT. Technicians with specialized training in diagnostic repair and service keep the department's one hundred and seven density gauges operating efficiently for use in acceptance of base, intermediate and surface materials. This performance measure is designed to evaluate the timely completion of the annual maintenance and calibration of WSDOT's nuclear density gauges and monitor annual efficiency.

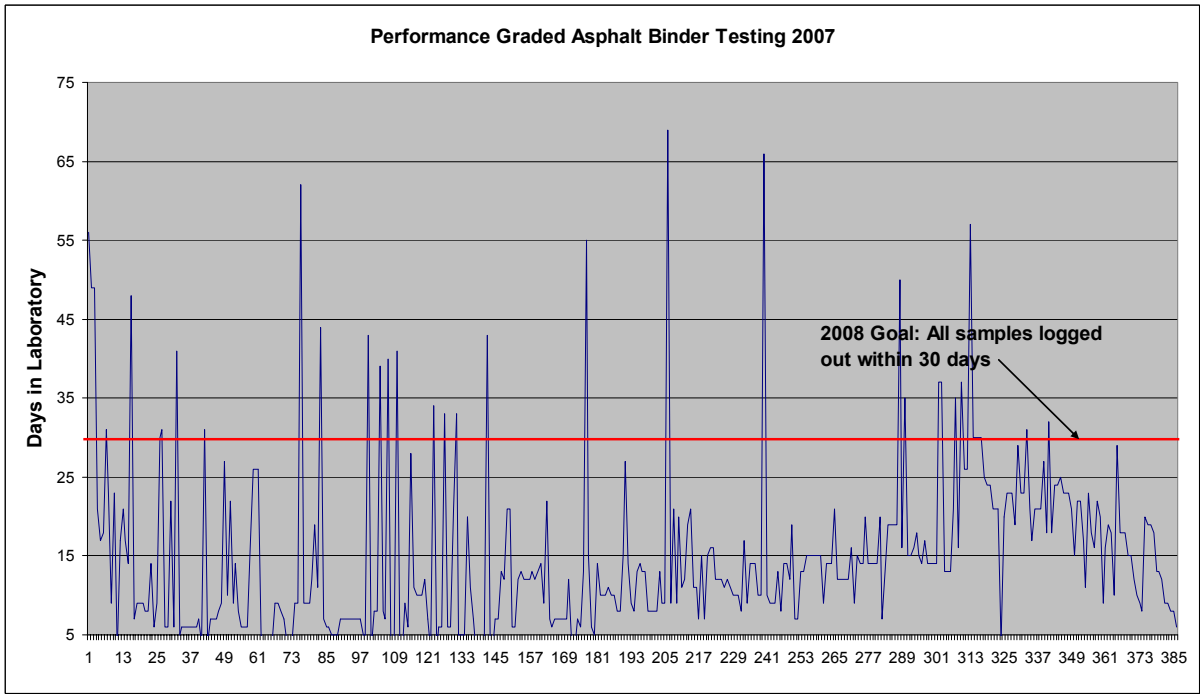
On average it takes three months to complete the maintenance and calibration of all the gauges so this work is scheduled in the winter months when most density gauges are not in use on construction projects. Repairs to the density gauges are performed throughout the year as needed. Performing maintenance, calibration and repair by trained WSDOT staff results in considerable time and cost savings to the department. Shipping, calibration, maintenance and repair costs would be significantly higher if this work was outsourced. The turnaround time of outsourcing this work would also impact the time sensitive testing on construction projects.



Performance Graded Asphalt Binder Testing 2007

As stated in the Construction Manual section 9-5.7 "Acceptance Sampling and Testing Frequency Guide" PG asphalt binder samples for verification are taken for every 1600 tons of Hot Mix Asphalt (HMA) produced on a construction project. A typical 1.6 million ton construction season would equate to 1,000 verification samples.

Due to the large volume of samples received during the construction season, the Liquid Asphalt Laboratory does not test all samples. For PG samples the first, third, fifth and every fifth sample thereafter are tested per contract, per supplier. If a sample does not meet specification, previous and subsequent samples are tested until the window of failure is captured. This policy brackets any failing samples, indicating the extent of the failure.



The 2008 Bituminous Materials Section goal for testing Performance Graded Asphalt Binders is to have all samples are tested and logged out within 30 days. Due to different testing temperatures used with different grades of PG binders, additional samples outside the normal testing protocol may need to be tested in order to achieve the 30 day goal.

Chemistry Section Performance Measure

Routine Samples Should Be Completed Within the Specified Turn-around Time.

In addition, information regarding routine samples for the purpose of representation was divided into two time frames (2 - represents tests conducted after June 26).

Routine samples fall into three broad categories:

1.) Those that can reasonably be completed in **5 working days** from log-in at the Receiving desk to Reporting-out from the Chemistry Section.

Paint	81%	84% *last year*	*3% less*
Paint (2)	93%	84% last year	9% *improvemen*t
Fencing	76%	78% *last year*	*2% less*
Fencing (2)	99 %	78% last year	12% *improvemen*t
Conduit	77%	83% *last year*	*6 % less*
Conduit (2)	*94%*	*83% last year*	*11% improvement*
Lane Markers	91%	92% *last year*	*1% less*
Lane Markers (2)	91%	92% *last year*	*1% less*

2.) Those that can reasonably be completed in **10 working days**

Joint Materials	92%	81*% last year*	*11% improvement*
Joint Materials (2)	100%	*81%last year*	19% *improvement*

3.) Those that can reasonably be completed in **17 working days** from log-in at the Receiving desk to Reporting-out from the Chemistry Section.

Epoxy	65%	85*% last year*	*20% less*
Epoxy (2)	100%	85 *% last year*	15% *improvement*

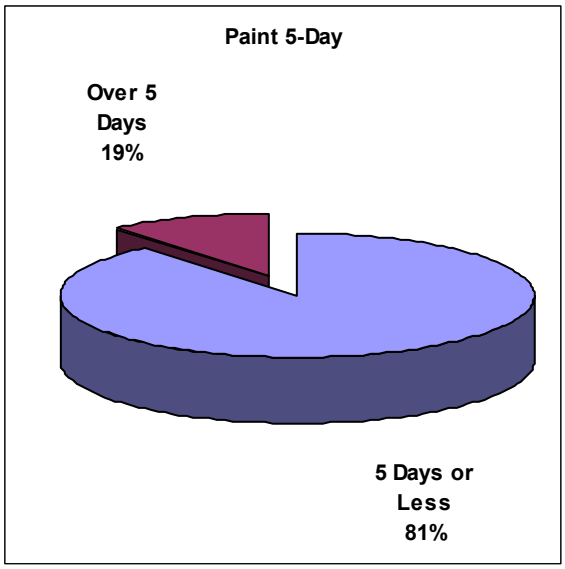
NOTE: Incomplete samples, samples with improper transmittals, and samples that require special handling, generally require longer than expected completion time.

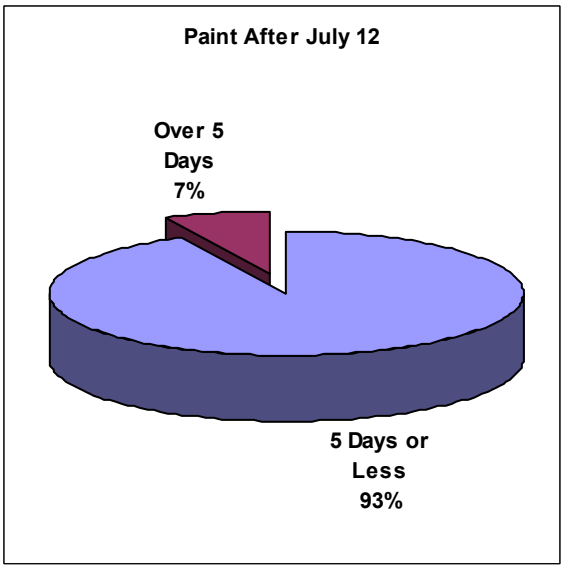
One material category (Lane markers) met the completion time performance goal for more than 90% of the samples.

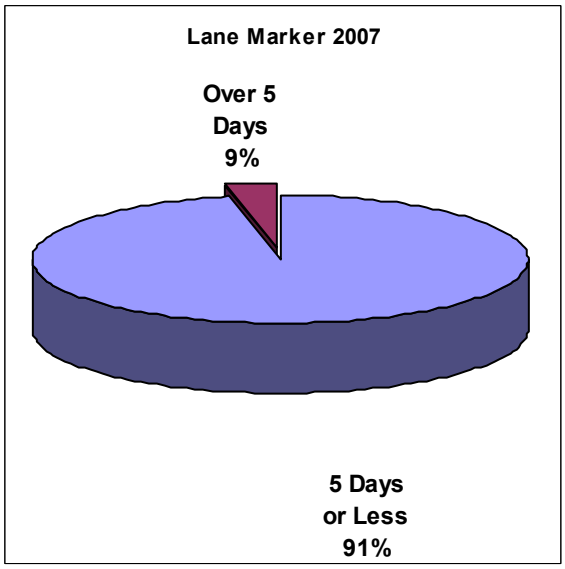
Three material categories (Paint, Conduit & Joint Materials) met the completion time performance goal for 80% (+) of the samples.

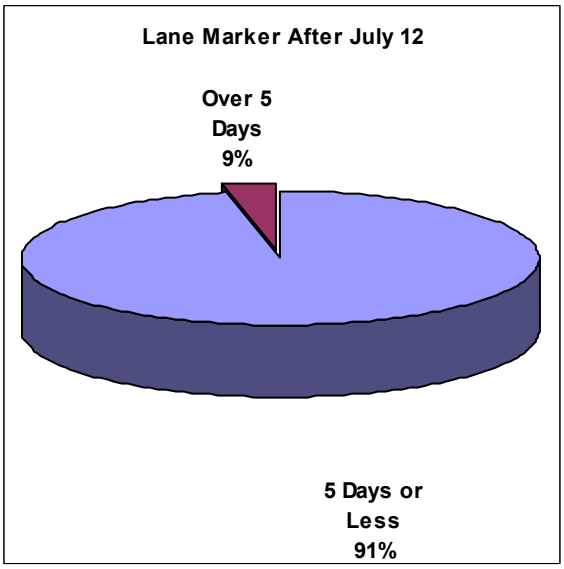
One material category (Fencing) met the completion time performance goal for more than 70% of the samples.

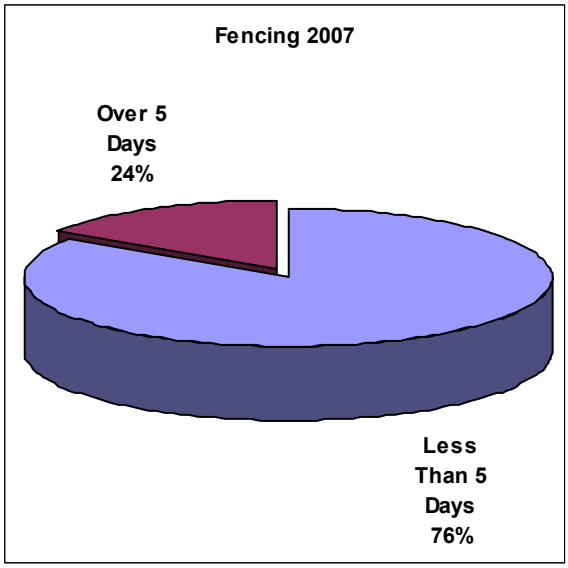
One material category (Epoxy) did not meet the completion time frame goal for 80% (+) of the samples for full year; however, this material category tests were completed 100% within turn-around time after June 26, 2007.

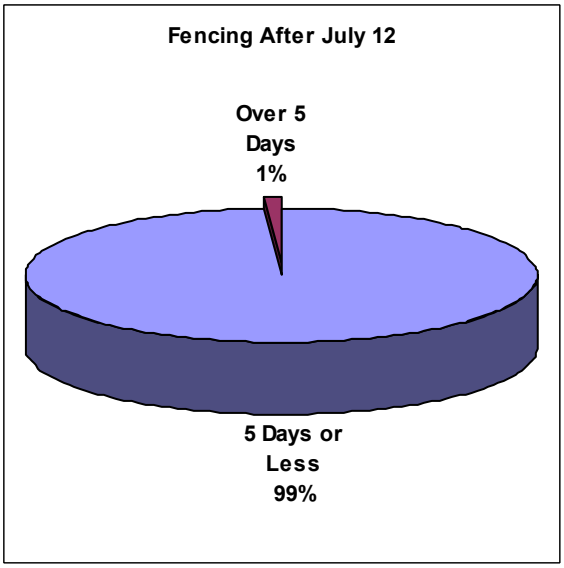


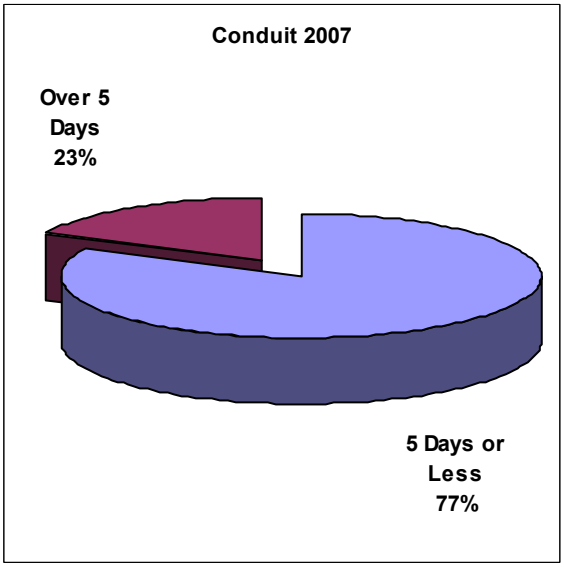


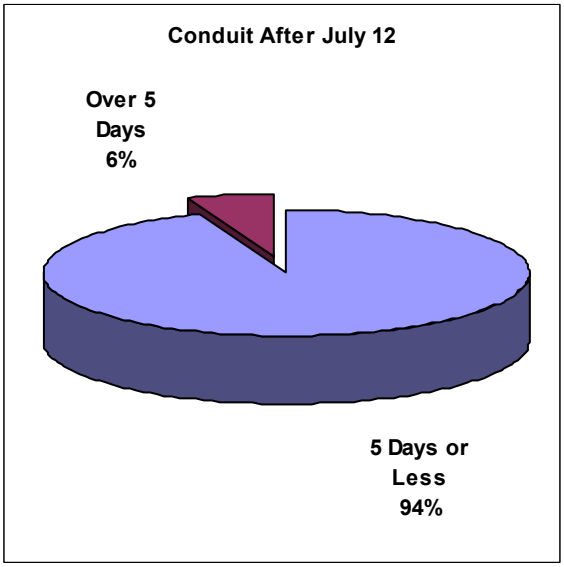


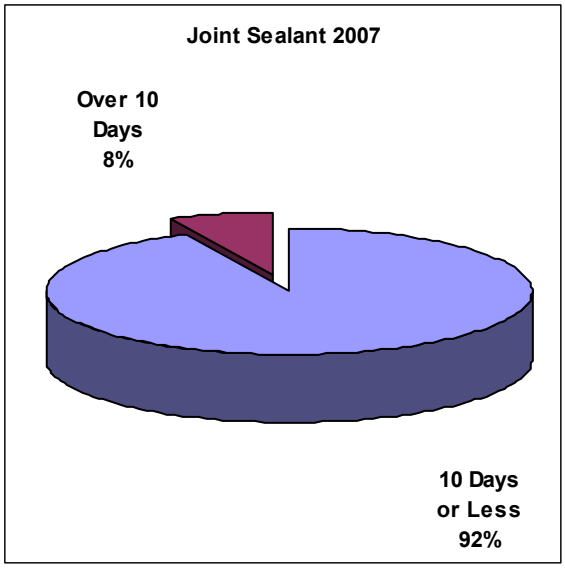


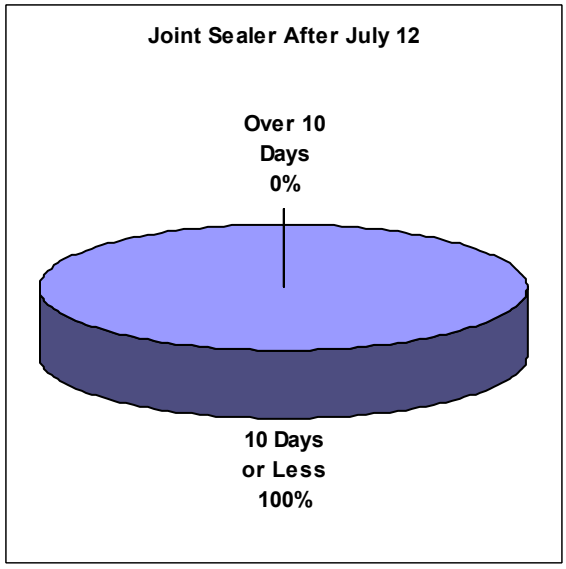

Fencing 2007
Over 5 Days 24%
Less Than 5 Days 76%

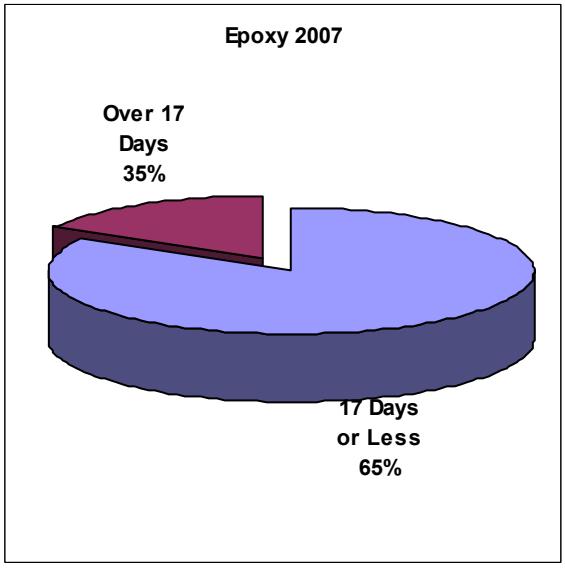

Fencing After July 12
Over 5 Days 1%
5 Days or Less 99%

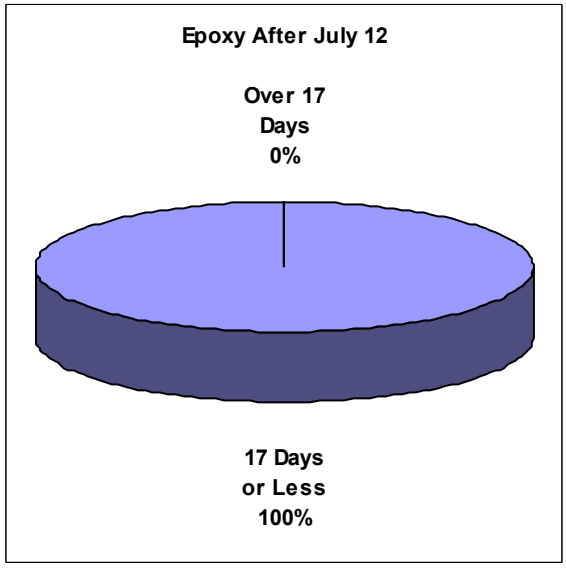

Conduit 2007
Over 5 Days 23%
5 Days or Less 77%


Conduit After July 12
Over 5 Days 6%
5 Days or Less 94%


Joint Sealant 2007
Over 10 Days 8%
10 Days or Less 92%


Joint Sealer After July 12
Over 10 Days 0%
10 Days or Less 100%


Epoxy 2007
Over 17 Days 35%
17 Days or Less 65%


Epoxy After July 12
Over 17 Days 0%
17 Days or Less 100%

Electrical Section Performance Measure

Traffic Controller Evaluation

The attached stack bar chart titled Performance Measures 2007 represents the amount of time used for each of the traffic controller assembly tested at the Materials Lab from 9/30/2006 to 10/1/2007. The total length of the bar represents the total time the controller assembly was resident at the lab for testing. The bar is divided into two sections the upper section represents the amount of time used by the lab to complete the evaluation of the controller assembly the bottom section represents the amount of time spent waiting for the vendor to correct problems discovered during the evaluation.

The average number of days required to complete the evaluation of a traffic controller assembly for the period of 9/30/2006 and 10/1/2007 was 38 days as compared with 33 from the previous reporting period. During the same reporting period the average Vendor Delay climbed from an average of 25 days to an average of 31 days while the average Test Time was 7 days. Presented in the following table are the statistics of each of the distributions: Total Time, Vendor Delay, and Test Time, for 2005, 2006 and 2007.

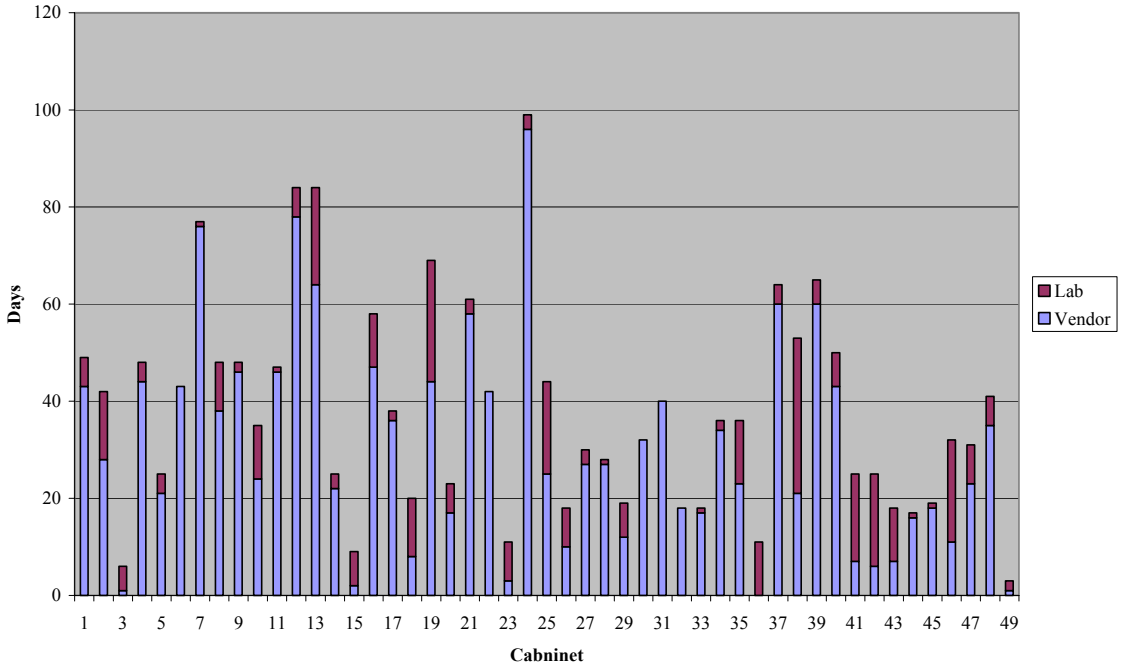
Year	2005			2006			2007		
days	Total Time	Vendor Delay	Test Time	Total Time	Vendor Delay	Test Time	Total Time	Vendor Delay	Test Time
Average	43	30	13	33	25	9	38	31	7
Max	173	165	83	104	87	41	99	96	32
STD	36	35	16	21	21	9	22	22	7

In an analysis of the data used in the chart the average testing time climbed to 38 days from the 33 shown for last year. Based on the data there does not appear to be an explanation for this increase in average test time, however, recent shifts in the way the traffic signal industry is organized has made it cumbersome for the suppliers to respond to problems. The goal for this next year will be the same as last year, to not let the testing time go past 29 days and be more proactive with the suppliers.

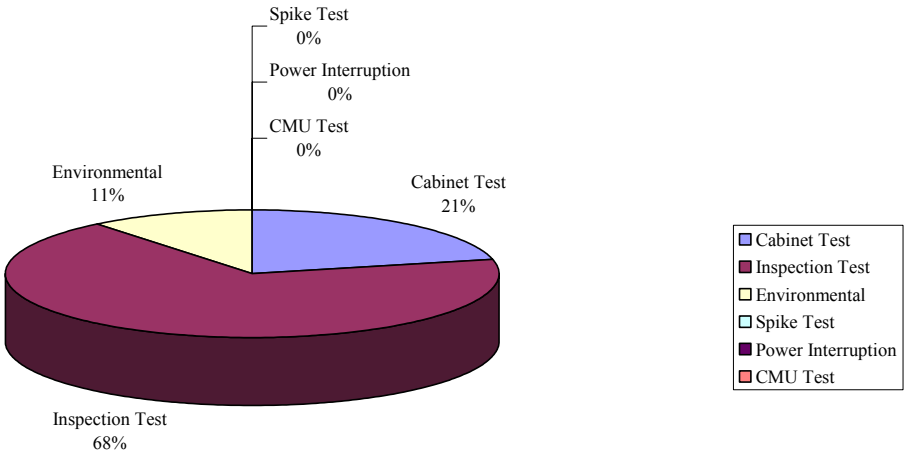
During the reporting period of 10/01/06 to 9/30/07 a total of 49 traffic controller cabinet assemblies were tested. There was a total of 263 nonconforming items identified while testing the 49 cabinets. The chart titled “Vendor Performance” shows the distribution of the nonconforming items with respect to the test that identified the nonconforming item. This chart is included to provide information on the continued tracking of nonconforming items seen during traffic controller assembly testing. The most interesting feature the chart is that more than 80 % of the identified nonconforming items continues to be found with a simple inspection and wiring test.

Performance Measures

September 2006 to October 2007



Vendor QualityPerformance



Construction Materials Administration

Quality Systems Performance Measure

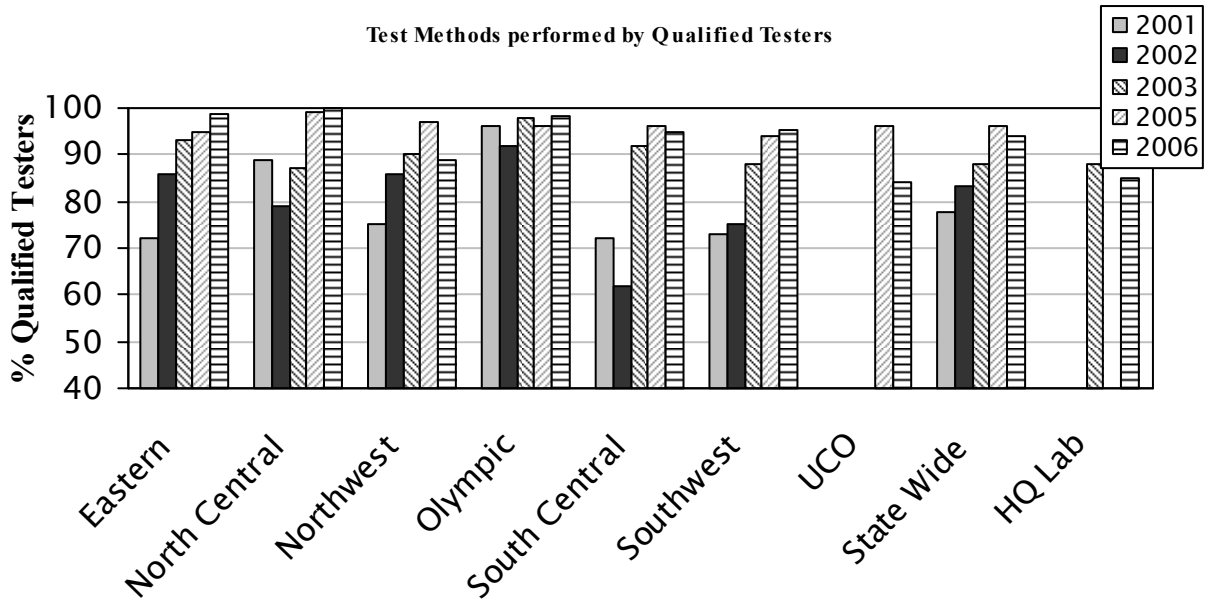
WSDOT Qualified Tester Program

On June 25, 1995, the Code of Federal Regulations (CFR) changed to require all State Transportation Departments doing work on the National Highway System to have Qualified Testers and Verified Equipment. Further, State Departments of Transportation were required to have their Central Materials Laboratory accredited by the American Association of State Highway and Transportation Officials (AASHTO) Accreditation Program (AAP). The Washington State Department of Transportation (WSDOT) State Materials Laboratory received AASHTO Accreditation on July 1, 1996 and has been re-accredited on an annual basis.

WSDOT developed and implemented a Qualified Tester / Verified Equipment program that the Federal Highway Administration (FHWA) approved in May 1997. A hands-on training program, with on the job training as a key element, provided the education to qualify our materials testers. The CFR required that by June 2000, all sampling and testing performed by WSDOT had to be performed by qualified testers using verified (calibrated) equipment. WSDOT met this requirement before the June 2000 deadline.

Qualified tester performing air entrainment test on fresh concrete. The air content of concrete is an important performance measure of its freeze-thaw durability.

In 2001, one year after full implementation, the WSDOT State Materials Laboratory conducted an audit of construction projects built in 2000, to see how well the qualified tester program was working. The audit found that 77.6% of the acceptance testing was being performed by qualified testers.



Source: WSDOT Materials Laboratory

Audits have been annually performed since 2001, the WSDOT State Materials Laboratory visited all of the project offices in each region last year and audited the 2006 project records to see what progress was made toward the goal of using 100% qualified testers.

On an average, in 2006 qualified testers performed 94.3% of our acceptance testing. This is reduction from last years rating of 96%. We are currently in the process of collecting data for our 2007review and have seen improvements in several areas .

During a Federal Highway Administration (FHWA) review of the WSDOT's Qualified Tester Program, they observed, "WSDOT is strongly committed to providing for qualified testers on all WSDOT contracts." Top management at WSDOT believes in the end result that qualified testers can bring to project work. As a result the DOT is committed to providing funding, time and equipment to support the program." FHWA recommended that, "Although WSDOT is meeting the intent of the regulations, there is always room for improvement. WSDOT is encouraged to continue to improve upon their compliance rate. In reality, it may be impossible to achieve 100% of all tests being performed by qualified testers, but the program can always be enhanced with more training, more funding and continued support from management." Final Report of the FHWA Washington Division Review of WSDOT Qualified Tester Program, By Cathy Nicholas

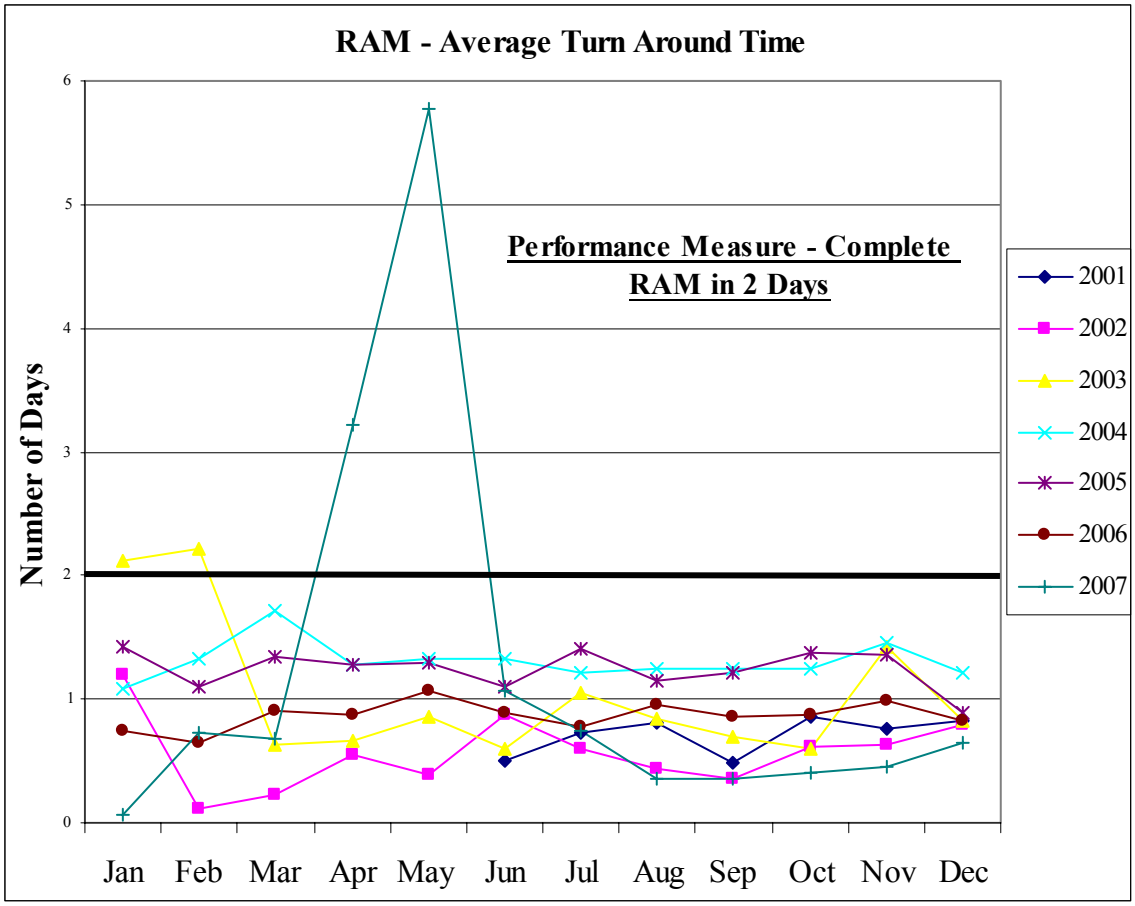
Materials Documentation

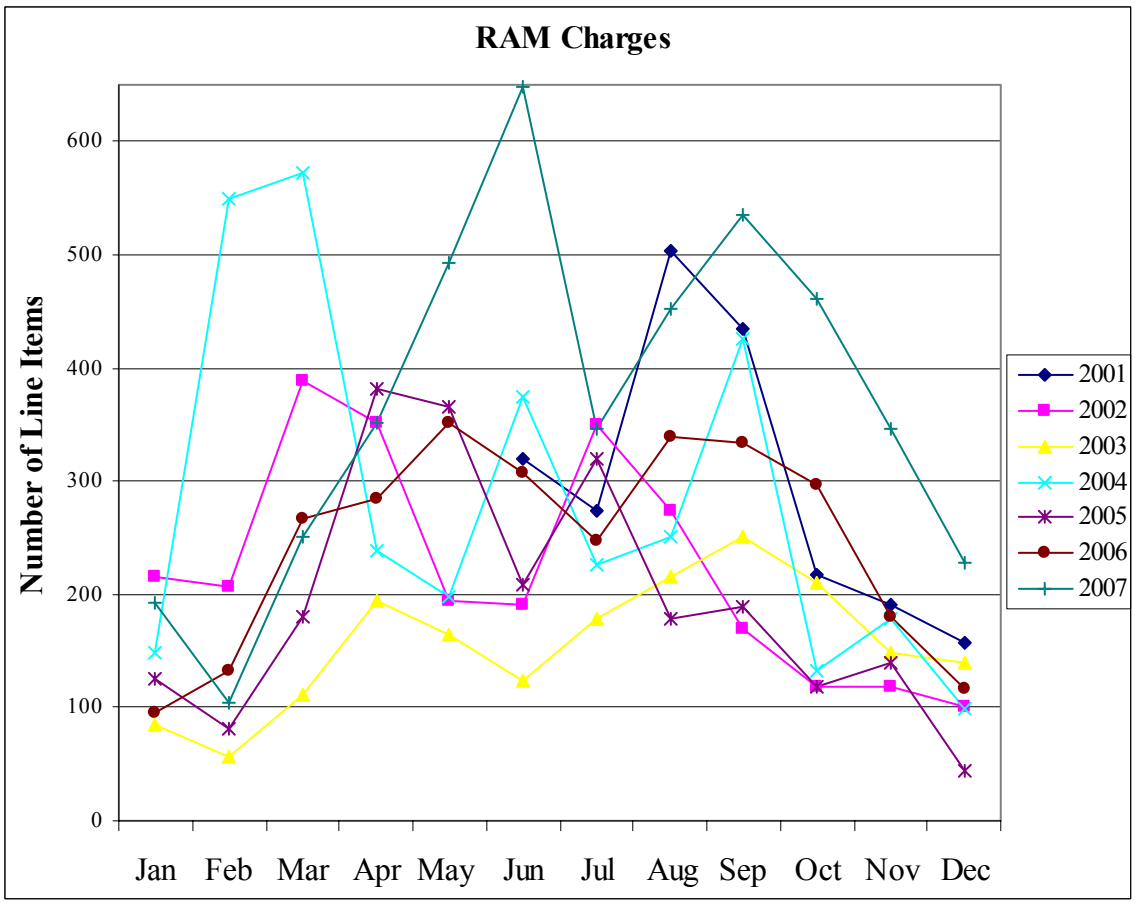
Performance Measure for Request for Approval of Material

A Request for Approval of Material (RAM) is prepared by the Contractor and submitted to the PEO (Project Engineer's Office) for each product or material anticipated for use on a construction project. The purpose of a RAM is to approve a product or material prior to it being placed on a construction project. Depending on what is known about the product or material, testing may be done to determine if the product or material meets the requirements of the contract.

The RAM is processed by the PEO and forwarded to the Materials Laboratory Documentation Section when the Project Office has insufficient information to approve the product or material. An alternate to submitting a RAM could be choosing a product or material already evaluated and approved via the QPL (Qualified Products List) process.

The Documentation Section's Goal is to complete all RAMS within two days of receiving the RAM. The performance goal was developed based on past turn around time for processing each RAM. Prior to approving a material or product on a RAM we often will need to consult with various Subject Matter Experts within WSDOT to gain concurrence to use the product or material.


RAM - Average Turn Around Time
Performance Measure - Complete RAM in 2 Days
Number of Days
0
1
2
3
4
5
6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2001
2002
2003
2004
2005
2006
2007


RAM Charges
Number of Line Items
0
100
200
300
400
500
600
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2001
2002
2003
2004
2005
2006
2007

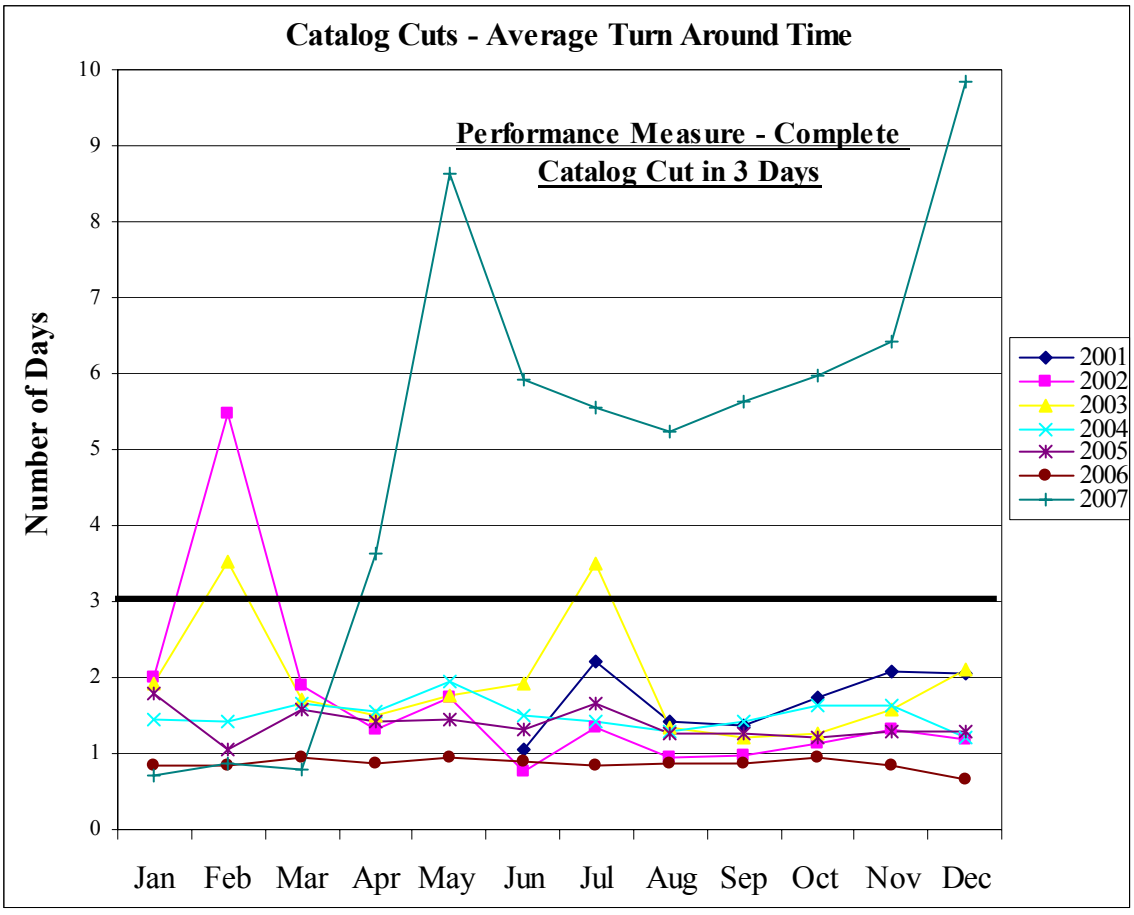
Performance Measure for Catalog Cuts

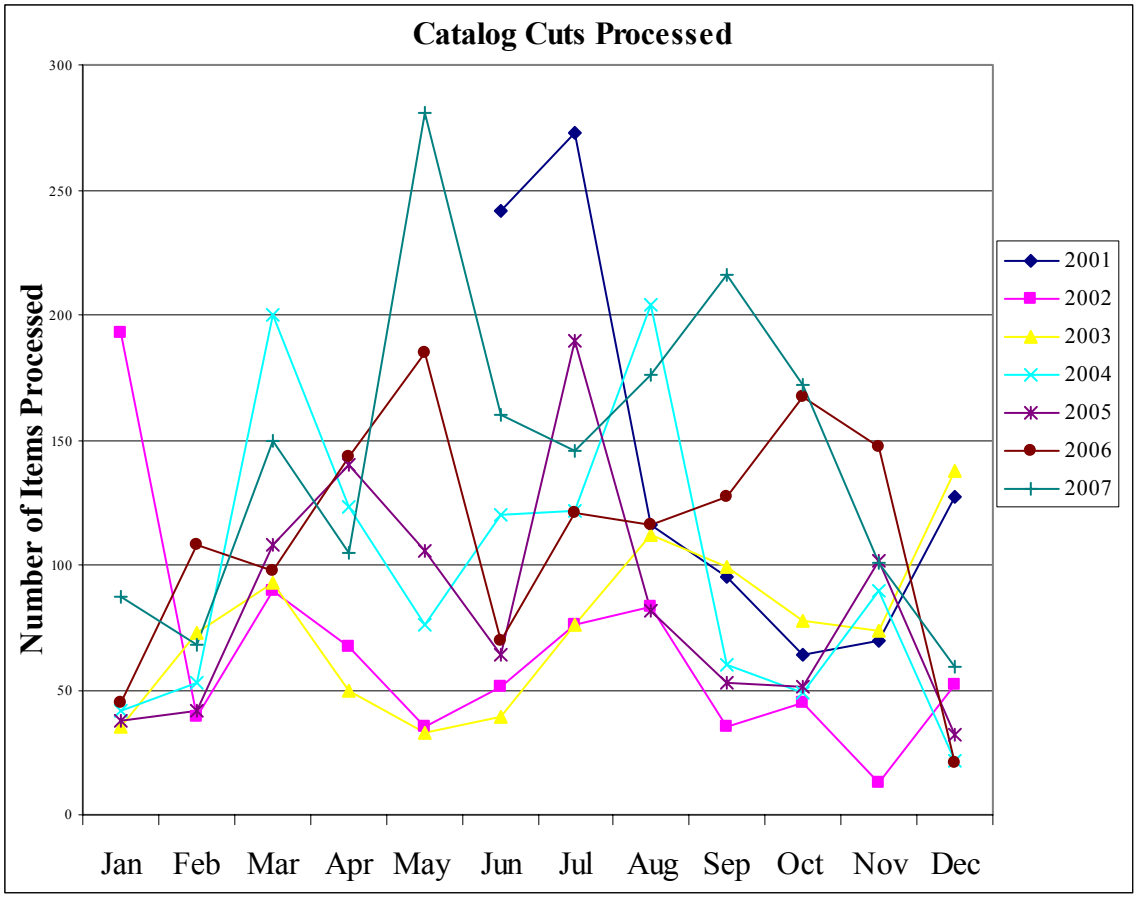
The review of Catalog Cuts is a method of verifying, for approval, products within the Request for Approval of Material (RAM) process. The purpose of a Catalog Cut review is to assist in verifying that particular products meet specification prior to placement on construction projects. If necessary the make, model, lot, brand, color, size, etc. is passed on to the Subject Matter Expert to assist in determining if the product meets the contract requirements. The Catalog Cut itself may consist of a brochure, actual copy from a catalog page that references AASHTO, ASTM or other standards that reference specified make, model, or size.

A Catalog Cut may be prepared by the Contractor and/or the Project Office and will be submitted to the Materials Laboratory Documentation Section for a particular product anticipated for use on a construction project.

The Materials Laboratory Documentation Section processes a Catalog Cut when the Project Office has insufficient information to approve a product. Submitting product for testing either by the State Materials Laboratory or an Accredited Independent Laboratory is an alternate to submitting a Catalog Cut.

The Documentation Section's goal is to complete all Catalog Cuts within three days of receiving the RAM. The performance goal was developed based on past turn around time for processing Catalog Cuts. Prior to approving a material on a Catalog Cut the documentation section often needs to consult with various Subject Matter Experts within WSDOT to gain concurrence to use the product.





Performance Measure for Compliance Reviews

As part of the WSDOT's Stewardship Agreement with the FHWA, the WSDOT is required to review contract compliance in the materials documentation area, these compliance reviews are a "spot check", verifying compliance with WSDOT's materials documentation requirements. The Materials Documentation Section of the State Materials Laboratory has been tasked with conducting Compliance Reviews and acting as unbiased auditors verifying contracts meet materials documentation requirements.

The requirements are covered in the WSDOT Construction Manual 9-1.5, Material Certification - Compliance Review for Materials Certification Process. A Compliance Review is performed on at least one contract for each project office once every two years. The reason Compliance Reviews are performed is to review previous materials documentation, assist Project Offices in maintaining adequate materials acceptance practices for future contracts, and to be proactive in initiating possible changes to the Construction Manual and Standard Specifications.

The Compliance Review findings are discussed with Project Office personnel during the wrap-up meeting after the review. A final letter covering the compliance review findings is then prepared and shared with WSDOT and the FHWA to document the Compliance Review findings.

Tracking and Charting Compliance Reviews

Each item reviewed during the Compliance Review is evaluated, tracked, and charted in the following areas.

- Field Verification

Was the material verified in the field by the inspector for what material was approved to be used by the RAM/QPL and proper acceptance criteria?

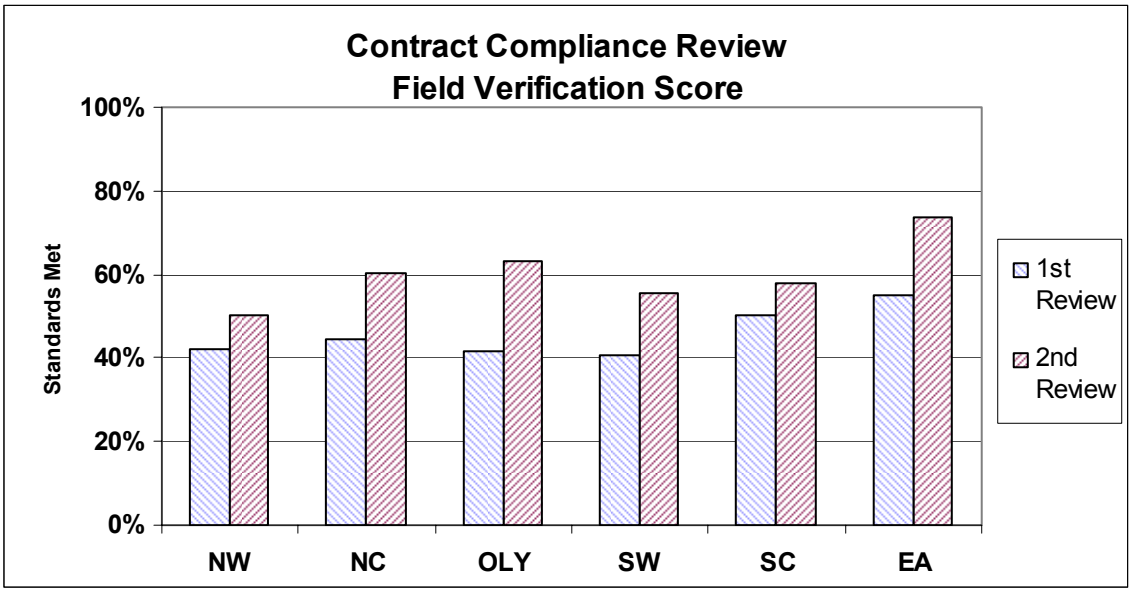
- Office Materials Documentation Score

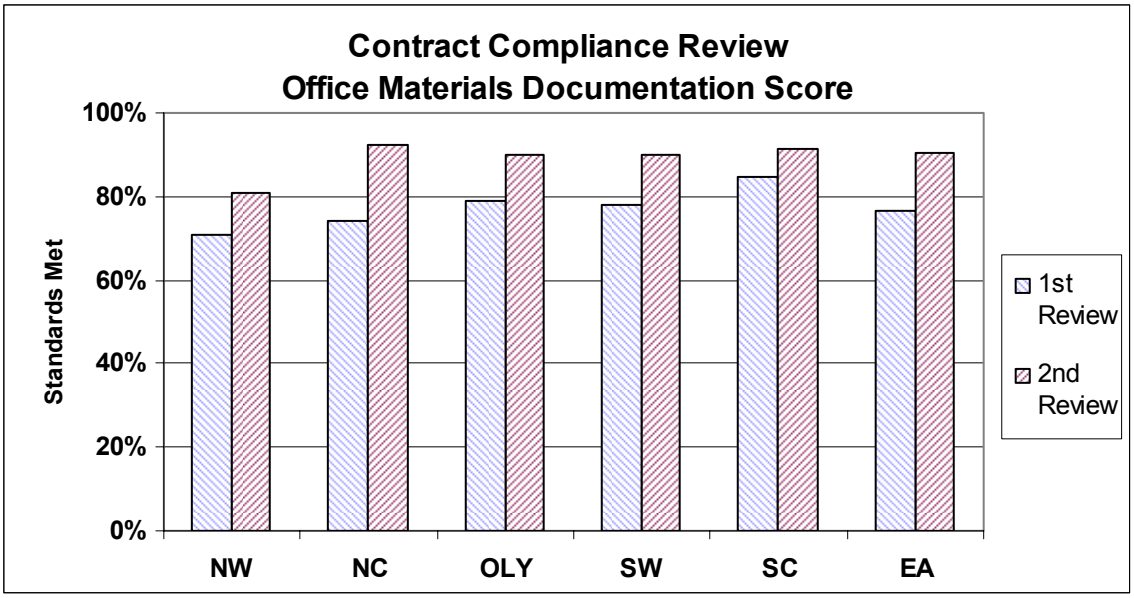
  Each criterion mentioned below counts 25% of the Office Materials Documentation Score.

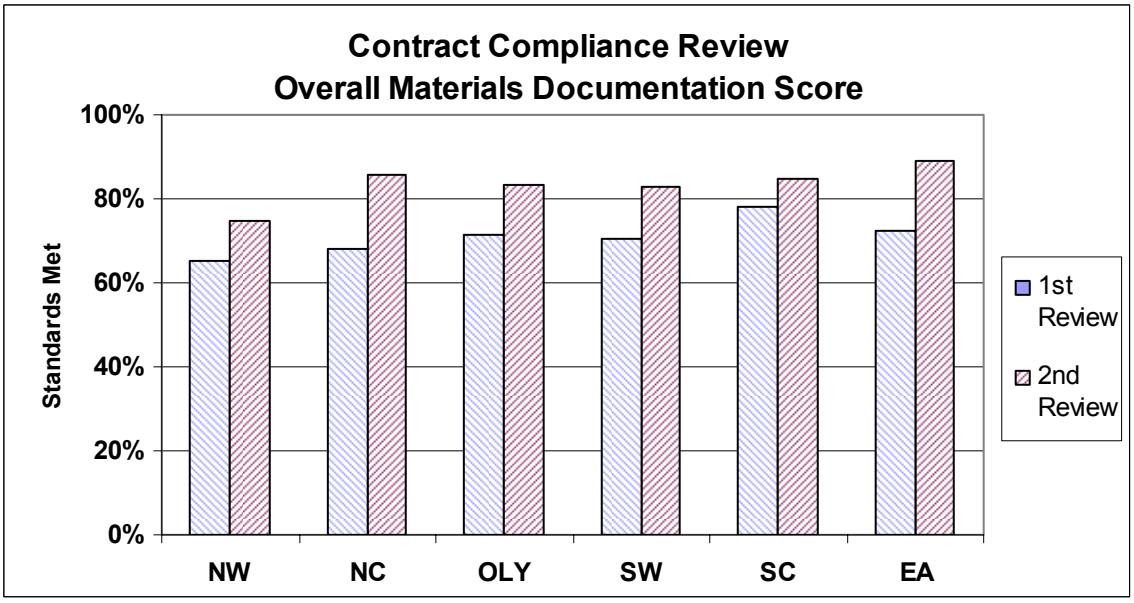
  - Were the Pay Ledger and Field Note Records consistent for materials paid?
  - Was the maintained ROM (tracking program) being kept up for quantity used, proper materials acceptance, and other documentation requirements as needed per 9-1.5 and 9-1.5A of the Construction Manual?
  - Was a RAM or QPL used prior to material placement and used correctly per 1-06.1 of the Standard Specifications and 9-1.5B of the Construction Manual?
  - Was the proper acceptance criteria received and approved prior to placement, i.e. Acceptance Sample, Catalog Cut, Manufacture Certification of Compliance, Approved for Shipment 'Tag' or 'Stamp' or Shop Drawing per the Standard Specifications, Standard Plans, Construction Manual and the Contract Specials and Plans?

- Overall Materials Documentation Score

  The four parts of the Office Materials Documentation Score are added to the Field Verification Score and then divided by "5".







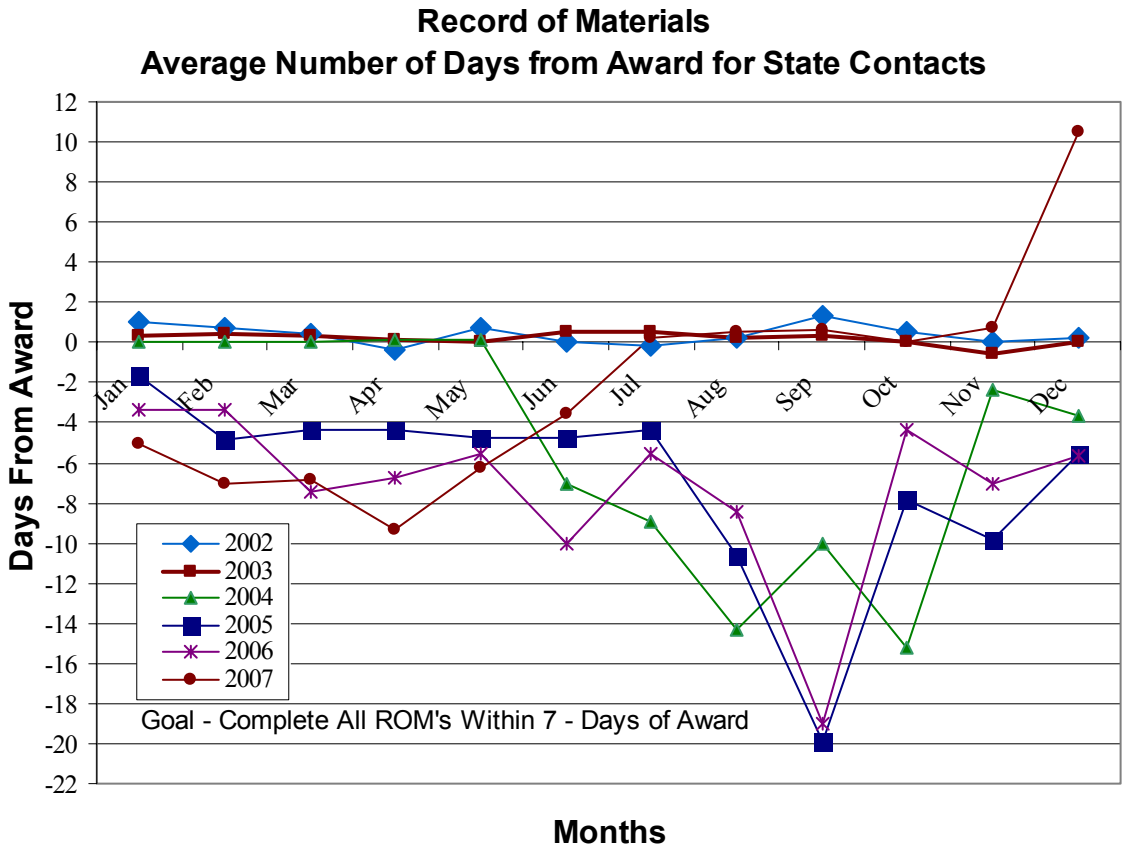
Performance Measure for Record of Materials

A Record of Materials (ROM) is prepared by the Materials Laboratory Documentation Section for every WSDOT construction contract and many local agency construction contracts. The ROM report is a list of all major construction items intended for use on each specific contract, taking into account the contract which includes Contract Provisions, Contract Plans, Standard Specifications, Construction Manual, Standard Plans and the quantities of those materials deemed to require acceptance testing. It further identifies the minimum number of acceptance and verification samples required for acceptance of those materials, with reference to total quantities and respective specification criteria. Also listed are products requiring other actions, such as fabrication inspection, manufacturer's certificate of compliance, shop drawings or catalog cuts that may need to be performed or acquired prior to installation of each material in the field.

The ROM is processed by the Documentation Section and forwarded electronically to every Project Office or appropriate Local Agency. The office administering the construction project

can then provide this information to the Contractor and/or use it themselves to determine appropriate testing frequencies and acceptance criteria for each material or product used on the project.

The Documentation Section's goal is to complete the ROM within seven days after the contract is awarded. The performance goal was developed based on feedback from regional personnel and the necessity to wait as long as possible to allow for incorporating any last minute addendum that may apply to the contract.



Construction Materials Structural

Materials Fabrication Inspection Performance Measure

Crosshole Sonic Logging Testing (CSL)

The Materials Fabrication Inspection office performs all In-plant inspections for all WSDOT construction contracts for roads and bridges. 11 years ago the fabrication office started providing CSL testing to the Regional Project Engineer's office throughout the State.

The performance measure will track our response time in performing CSL testing, from the test date requested by the Project Office to the date of actual testing. The goal is to respond no later than 48 business hours from the test date requested.

This information will be used to track our efficiency in responding to the project engineer's office request for CSL testing and also maximizing the scheduling of in-plant inspection of our inspectors.

These Performance Measure charts and graphs illustrate the relationship of CSL testing date, as it relates to request dates for CSL testing. They are divided into:

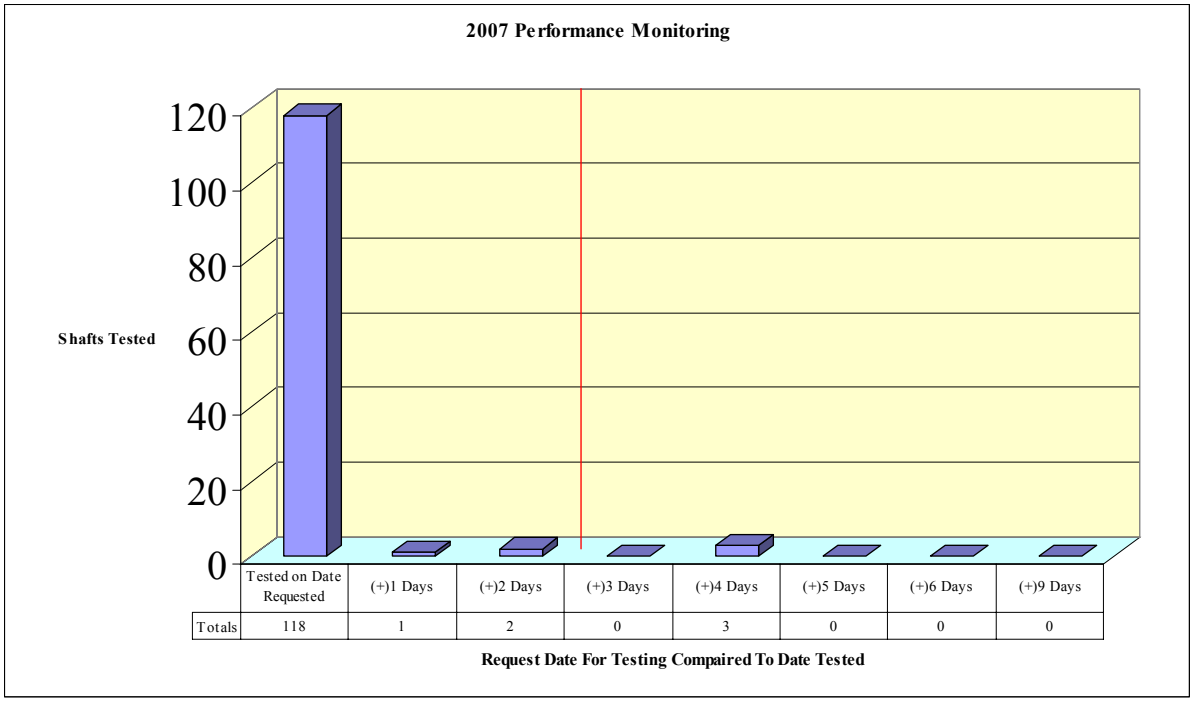
- Breakdown: Shows all test locations and the date tested under the number of business days since the date requested for testing.

- Notification: Table of number of days from date request for testing until testing with corresponding graph.

- Comparison: Compares cumulative percentage of annual testing from 2005 to 2007, broken down from the request date until actual date tested.

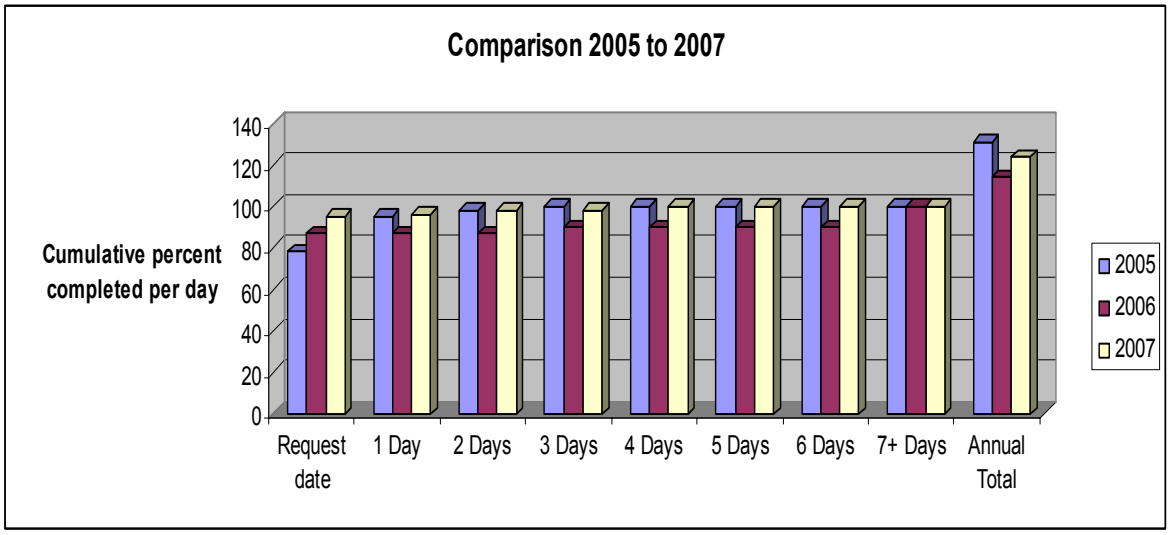
Crosshole Sonic Logging Performance Monitor 2007

A Total of 124 shafts were tested in 2007, of these 121 were tested within the two day specification. The remaining 3 were able to be rescheduled to accommodate workload and staffing between contractor and WSDOT.



Comparison 2005 to 2007

The cumulative percentage of the annual total testing by the number of days from the date requested until data acquisition was actually obtained. The target is for 100% of the testing to be completed no later than two days from the request date for testing.



	2005	2006	2007
Request date	78	87	95
1 Day	95	87	96
2 Days	98	87	98
3 Days	100	90	98
4 Days	100	90	100
5 Days	100	90	100
6 Days	100	90	100
7+ Days	100	100	100
Annual Total	131	114	124

The deviance from compliance with the 2 day specification is attributed to scheduling of both WSDOT and the contractor, and obtaining access to the test area after the drilling equipment has been moved.

Geotechnical Performance Measures

Productivity Measures

The Geotechnical Division provides statewide geotechnical (foundation engineering and engineering geology) design, construction, and maintenance support services for WSDOT. For performance measurement purposes, The Division's services can be subdivided into three primary functions, which include field exploration services, geotechnical design services, and P3 program unstable slopes technical management.

An important measure of our service to the Region offices, the Marine Division, the Bridge Office, the Office of Program Management, and other key customers statewide is how well we keep our commitments regarding costs and completion time. For geotechnical design, this measure has been accomplished by tracking the number of design hours to complete the geotechnical portion of a project, and comparing that value to the hours estimated for the project. In 2007, however, the performance measure for geotechnical design was switched to design cost. Similarly, for field exploration, tracking the field exploration cost to complete the geotechnical field investigation for a project, and comparing that value to the field exploration cost estimated for the project accomplish this measure.

Another measure of productivity that can be applied to the Field Exploration activities is the cost per foot of test hole drilling. The cost per foot is dependent on a number of factors, including:

- the type of drilling equipment used,
- the travel distance and difficulty encountered in getting the drilling rig to the test hole location,
- the nature of the soil/rock encountered during the drilling (e.g., bouldery soils are much more difficult to drill through than uniform sands and silts), and
- the productiveness of the drill crew.

Therefore, comparisons must be made for similar equipment in similar drilling and access conditions.

Performance measures have been in place for the Geotechnical Division since the latter half of 2001. Due to the fact that the position responsible to compile and track the design project performance data for the Geotechnical Division was vacant most of 2006, no design project performance data is available for 2006. Since 2006, due to changes in how the Division is tracking projects, this performance measure is now based on estimated versus actual (billed) project costs rather than hours. Since a direct comparison between the current year statistics and previous years' statistics cannot be made due to this change, the previous years' statistics are not provided. For 2007, comparisons between the estimated and actual (billed) costs needed to complete a project geotechnical design are provided in Figure 1. A ratio (costs billed/estimated costs) of 1.0 means that the estimated costs and the billed costs are the same. A ratio less than 1.0 indicates the project was completed at a lower cost than estimated, which is desirable, provided that the estimate was not too much higher than the actual amount it took to get the job completed. A ratio greater than 1.0 indicates that billed costs were greater than estimated, which is undesirable. Our target is to have the estimate within 20% of the actual costs. If a change in scope for the project occurred after the final estimate was made, the estimate was revised only if

the revised estimate was communicated to the region in advance, as soon as the change in scope was known.

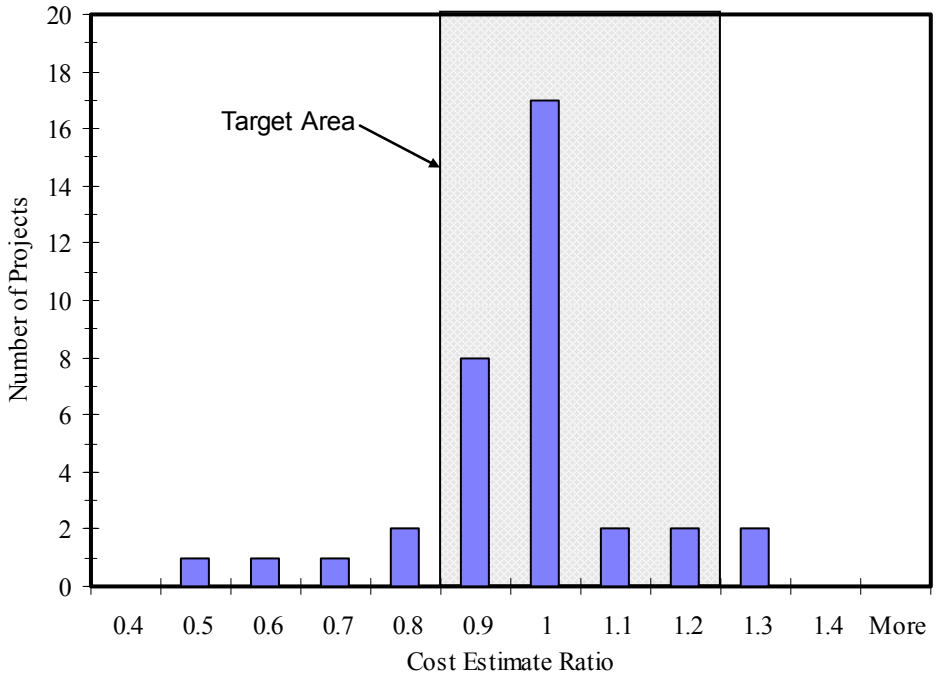


Figure 1. Ratio of billed costs to estimated engineering costs for geotechnical projects completed in 2007.

The number of projects that overran the estimate by more than 20% was only 6% of the total (36 total projects were completed in 2007, which is similar to the total number of projects completed each year since 2004). In previous years, based on estimated versus actual (billed) hours, the percent of projects that overran the estimate by more than 20% was typically around 20%. Overall in 2007, the percent of projects that overran or under-ran relative to the estimated project cost by more than 20% was 19%. In previous years, based on estimated versus actual (billed) hours, the percent of projects that overran or under-ran the estimate by more than 20% was typically around 40%. While a direct comparison to previous years cannot be made, in general the statistics for 2007 appear to be a strong improvement.

Figure 2 provides a comparison between the estimated and actual (billed) costs needed to complete the field exploration for a design project. A ratio (hours billed/estimated hours) of 1.0 means that the estimated hours and the billed hours are the same. A ratio less than 1.0 indicates the project field exploration was completed for less cost than estimated, which is desirable, provided that the estimate was not too much higher than the actual amount of time it took to get the job completed. A ratio greater than 1.0 indicates that more cost was billed than estimated, which is undesirable. Our target is to have the estimate within 20% of the actual cost.

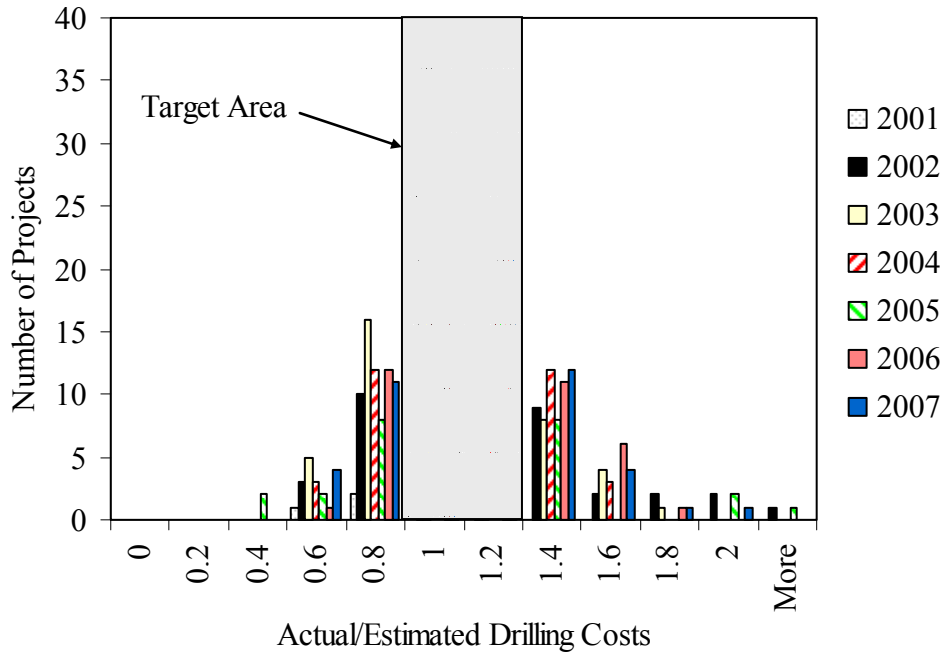


Figure 2. Ratio of billed costs to estimated costs for geotechnical field exploration services completed July 2001 through December 2007.

The statistics illustrated in Figure 1 can be summarized as follows:

Table 1. Summary of drilling project estimate statistics.

	2001 (last half)	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Total Number of Projects	8	74	93	82	71	83	83
Projects Outside of 20% Target Range (% of total)	38%	39%	37%	37%	32%	37%	40%
Projects More Than 20% Over Budget (% of total)	0%	25%	14%	18%	15%	22%	22%

Figure 3, which shows the difference between the estimated and actual drilling costs for each project, provides a more complete picture of the nature of the overruns in the drilling costs, in that most of the significant overruns are for small projects where a $5,000 overrun makes a big difference in the ratios. Based on Figure 3, we find that 18% of the field exploration projects were significantly more than $5,000 over budget (negative numbers indicate a cost overrun) in 2006. Just an extra day and half of drilling on a project can result in this type of cost increase, which can easily happen depending on the site conditions encountered or if equipment breakdown occurs. This is generally consistent with past years, in which 14%to 20% of the projects were more than $5,000 over budget. The fluctuation in the number of projects over budget reflects the many uncertainties in estimating the cost of geotechnical field exploration, as discussed in more detail below. Furthermore, this fluctuation is dependent on how aggressively the estimate is made, i.e., rather than estimating project costs conservatively, targeting greater accuracy in the estimate.

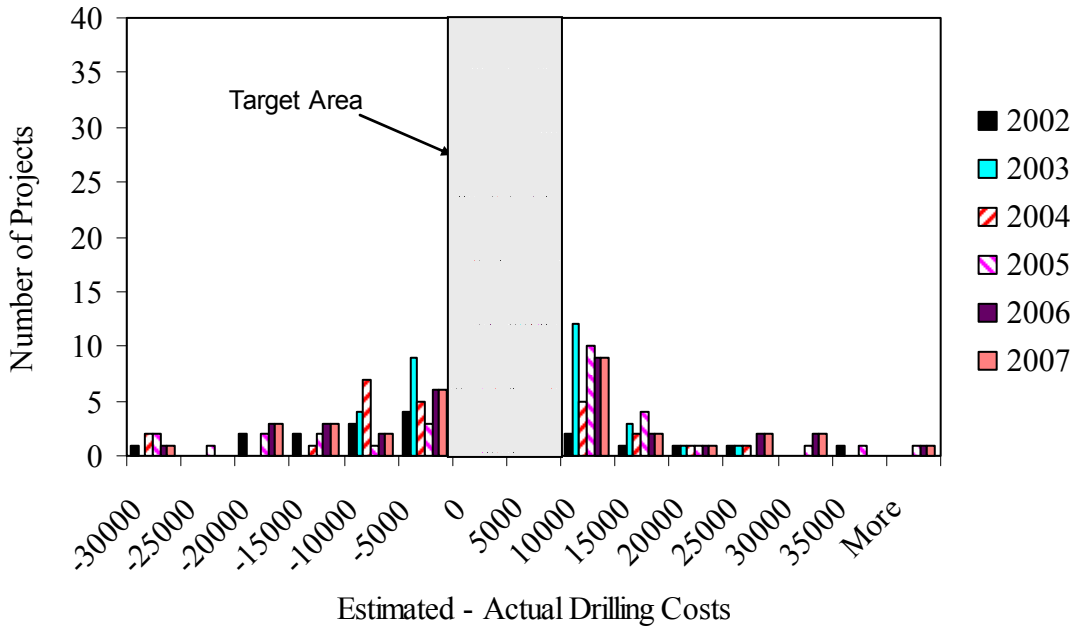


Figure 2. Estimated minus actual cost for geotechnical field exploration services completed January 2002 through December 2007.

It should be recognized that there are a lot of uncertainties in putting together estimates for geotechnical work, primarily due to the variable nature of the subsurface conditions which can affect the type and complexity of the design required, as well as the depth and number of test holes, probes, etc., needed to characterize those conditions. Scope changes during design can also affect the accuracy of the estimate. Continued improvement is needed to better track hours and cost estimates as the project progresses, and to immediately discuss the impact of any customer generated changes in scope with the customer, so that the estimate can be properly adjusted and planned for. This will be a goal for next year's performance. Furthermore, when a staff member gets overwhelmed with a project with complex ground conditions or overall project complexity, there is a tendency for other projects the person is working on to be delayed as well. Tracking these scope changes better and communicating them to the customer as early as possible, as well as attempting to head off the build up of delayed work earlier through redistribution of work to the staff will continue to be a focus area in 2008 regarding our project management.

In spite of the uncertainties in estimating geotechnical design and exploration costs, these performance measures have proven to be an effective tool to evaluate performance of crews and units within the Geotechnical Division. These performance measures allow us to closely monitor crew/unit performance and track project costs closely. It has increased our focus on the key aspects of the services provided by the Geotechnical Division. It has also allowed the crew/unit members to see what is expected of them and to follow their progress to completion of all projects. These tools have also proven useful to better communicate with our customers and to help develop realistic expectations regarding the scope and cost of services needed for a given project.

In the past, when criticism has been received, it has often been the result of unrealistic expectations, or poor communication between the Geotechnical Division and the customer regarding the project scope and the cost to accomplish that scope. The performance measures reported herein will continue to be used to insure that the project scope is properly assessed and communicated, and that expectations are realistic.

A benefit of these performance measures is the improved ability of Geotechnical Division managers to evaluate performance and make course corrections before problems get big and costly. This has been especially apparent when evaluating the performance of the field exploration unit. If the performance measures and their use by management are effective, cost decreases to deliver services should occur as inefficiencies are reduced or eliminated. Tables 2 and 3, which provide the unit cost per ft of test hole drilled (field exploration services), illustrate this point:

Table 2. Summary of average drilling costs for 2002 through 2004.

Type of Drill Rig	Average 2002 Cost/ft of Drill Hole			Average 2003 Cost/ft of Drill Hole			Average 2004 Cost/ft of Drill Hole		
	No. of Holes	Drill Footage (ft)	Cost/ft	No. of Holes	Drill Footage (ft)	Cost/ft	No. of Holes	Drill Footage (ft)	Cost/ft
All Rigs and Projects	362	17,166	$124.62	567	20,943	$114.20	689	29,357	$99.38
Track Mounted 850 Rig	60	2,771	$84.55	81	3,276	$116.76	104	4,733	$85.54
Truck Mounted Rig	67	2,259	$103.35	57	2,146	$97.35	49	1,134	$104.12
Skid Rig	40	1,818	$133.19	54	2,284	$136.30	43	1,770	$115.57
Barge Rig	24	1,952	$174.94	11	699	$108.36	26	2,030	$116.52
Multiple Rig Type Project	154	7,222	$149.91	334	11,576	$123.82	388	16,466	$106.14

Table 3. Summary of average drilling costs for 2005 and 2006.

Type of Drill Rig	Average 2005 Cost/ft of Drill Hole			Average 2006 Cost/ft of Drill Hole			Average 2007 Cost/ft of Drill Hole		
	No. of Holes	Drill Footage (ft)	Cost/ft	No. of Holes	Drill Footage (ft)	Cost/ft	No. of Holes	Drill Footage (ft)	Cost/ft
All Rigs and Projects	856	44,486	$90.91	826	43,893	$91.20	946	49,015	$91.93
Track Mounted 850 Rig	35	1,791	$66.71	38	2,246	$80.80	91	3,606	$105.04
Truck Mounted Rig	23	498	$81.44	41	2,174	$99.32	10	318	$89.20
Skid Rig	66	4,346	$121.57	29	2,247	$171.08	32	1,158	$123.47
Barge Rig	75	2,772	$121.61	3	793	$108.78	29	1,989	$192.15
Multiple Rig Type Project	662	35,620	$81.06	632	33,585	$101.12	698	38,720	$89.99
Hand tools	24	922	$9.41	83	2,848	$11.79	82	3,175	$17.29

While such comparisons on drilling costs must be made cautiously, as drilling cost for even the same rig type will be affected by the difficulty of the site subsurface conditions, traffic control restrictions, environmental permit restrictions, and variability in the difficulty and distance to mobilize the rig to the site, the general trend is that from 2002 to 2005, a significant decrease in drilling costs occurred each year. These cost decreases occurred in spite of increases during that time period in the cost recovery hourly rates that the Division must charge. These reduced per foot drilling costs have resulted in a total savings of over $1,000,000 from 2002 through 2005.

Tables 2 and 3 also illustrate another point: that there is a limit in the cost decreases that can be obtained through the use of performance measures. When looking at the 2006 drilling costs per foot, it can be observed that drilling costs per foot did not decrease for the fifth year in a row. From this point forward, what is important is to consistently maintain the reduced cost per foot of drilling. It should also be recognized the recovery rates that must be charged did increase again in 2006 relative to 2005. Therefore, to maintain the same cost per foot, drilling costs must be decreased to maintain the same cost per foot and offset the increased hourly recovery rate.

A major increase in the cost recovery rates occurred in 2007, primarily due to a significant increase in the base salary for technicians and engineers to catch them up to 25% below their peers in the private sector and other organizations outside of Washington state service. This resulted in an increase of 18% in the cost recovery rates by July 2007. Yet, in spite of this increase in the hourly rates, the overall cost/ft of drilling only increased $0.73 (0.8%) relative to 2006 costs, illustrating that a significant improvement in the cost effectiveness and efficiency of the WSDOT provided drilling services occurred in 2007. These continued cost decreases relative to the cost recovery rates are an exceptional accomplishment, worthy of recognition.

We believe that the reasons for these cost decreases have been as follows:

1. Performance measures provide opportunities for recognizing problems early, enabling field exploration managers to correct problems before they get expensive.
2. Adding a second Field Exploration Supervisor (FES) in 2003, and adding a third FES in 2007 due to an increase in the number of crews due to increased workload, has helped make the management of the Field Exploration Unit more effective, enabling highly

experienced managers to address problems in the field more quickly and to provide on-the-spot training of staff so that they can carry out their mission more effectively. Prior to 2003, the field exploration management team was spread too thin.

3. The performance measures have helped the individual crew members to recognize when they are falling behind, so that they can take ownership for improving the performance of their own crew (professional pride encourages the crew members to not be the poorest performers of the group). Note: the field exploration management is not openly encouraging direct competition between crews - this is done more informally through routine individual performance review by the FES's and the Field Exploration Manager.
4. The correction of the class specification problem a few years ago for the drill crews has contributed to a much improved work environment and improved work attitudes.
5. Estimating project drilling costs at the beginning of each project more aggressively (see discussion on this above), with less cushion, combined with strong encouragement to meet the more aggressive cost estimate, has helped crews to do everything they can to meet the more aggressive goal.

Comparison to Private Sector

For field exploration services, the drilling cost per foot can reflect the comparative efficiency of the service, provided the comparison is made between drilling projects which are similar in nature regarding the type of equipment used, the depth of the hole, the type of sampling and testing done, the drilling difficulty, and site access difficulty. This cost per foot can be used as the basis of comparison between the private sector and state forces for field exploration services, provided the conditions of project and equipment similarity mentioned previously are met. This generally requires that both the state forces and the private sector contractors be performing work almost side by side on the same project. Note also that comparisons between state forces and the private sector, on a cost per foot basis, must be made for organizations that have a similar ability to provide a variety of exploration services and to adapt to a variety of access conditions. For example, a drilling contractor who only has the ability to drill on the road (i.e., minimal off road access ability) will generally have a lower overhead cost than a contractor who has the ability to access test hole locations in any terrain conditions. The reason for this is the amount of drilling equipment that must be available for use at any time. A full service contractor simply costs more per foot of drilling than a drilling contractor who provides only limited access drilling services. Due to necessity, the Geotechnical Division Field Exploration Unit must have full service ability in all terrain conditions. A fair comparison can only be made to those drilling contractors who provide complete field exploration services at the same level provided by the Geotechnical Division.

A limited comparison between state force drilling costs and contractor drilling costs was provided in the 2001 Annual Report for the Materials Laboratory. It was found that for the few instances where a direct comparison could be made, state force drilling costs were approximately 20 to 30% less expensive than contractor drilling costs. In 2002, 2003, 2004, there were no projects available where such a comparison could be made due to reduced use of contract drillers during the period. However, since drilling costs per foot have gone down, it can be concluded that in-house drilling costs likely remained significantly below contract drilling costs. In 2005, there was one project where a direct comparison could be made, the SR-518 EB Widening Project. This project contained a lot of skid drill work. The contractor cost for their portion of the drilling was $180.01/ft, whereas the WSDOT drill crew drilling cost was only $94.69/ft. In

2006, there were three projects where such a comparison could be made. In those cases, WSDOT drilling costs ranged from 60 to just under 100% of the contractor drilling costs, averaging 75%.

In 2007, for one of the full service drilling contractors, their average cost for a series of projects with a total of 2,616 ft of drilling without the drilling inspector cost for skid or helicopter work was $219.72/ft. For WSDOT, for skid drill work, the average cost overall in 2007 without inspector costs was $79.63/ft.

While anecdotal, these examples show the cost effectiveness of the state drill crews.

Significant Programmatic Accomplishments for the Geotechnical Division in 2007

WSDOT Geotechnical Design Manual

Since its publication in September 2005, the Geotechnical Design Manual (GDM) has been in high demand from consultants, regionally and even nationally, and several other state DOT's are looking to the WSDOT GDM as the basis for developing their own geotechnical design manuals, and in some cases, using it verbatim. Furthermore, the FHWA continues to promote the WSDOT GDM on their geotechnical website as a model for other state DOT's to follow.

A significant update to the GDM was started in 2007, but will not be completed until mid-2008. This is discussed further below in the proposed accomplishments for 2008.

The manual has helped to define geotechnical design policies that in the past were nebulous and inconsistent in their implementation (e.g., liquefaction mitigation). The manual, especially with the recent updates, also more clearly defined the roles and responsibilities of various WSDOT offices, especially in the context of the WSDOT project management process.

LRFD Design Specification Implementation for Foundations and Walls

As indicated in previous annual reports, we have actively assisted the AASHTO Bridge Subcommittee and the FHWA to accomplish a rewrite of the foundation design sections in 2004 and 2005, as well as to gain the national acceptance needed in the AASHTO Bridge Subcommittee to get the rewrite approved. We also helped to develop the load and resistance factors used for LRFD foundation and wall design. The load and resistance factors are in effect safety factors, and directly affect how conservative, and therefore how costly, the resulting design will be. Several Geotechnical Division staff have continued to participate on NCHRP panels that have been set up to oversee research on load and resistance factor development for foundations and walls. It is our goal to keep the foundations and walls that we design as economically efficient as possible while providing a consistent level of reliability for the performance of these types of structures.

We are continuing to assist the AASHTO Bridge Subcommittee to develop the LRFD specifications for foundations and walls. A key major new design specification we have helped to produce that was added to the AASHTO LRFD specifications in 2007 is the design of micropile foundations. Micropiles provide an excellent foundation scheme for retrofit and repair

of foundations, as well as a useful foundation technique in foundation construction locations with limited room.

MSE Retaining Wall Research

Since 1990, WSDOT, with the help of a number of public and private sector funding partners, the University of Washington, and the Royal Military College of Canada, has conducted research on the internal stability of mechanically stabilized earth (MSE) walls. MSE walls are commonly used by WSDOT in situations where fill must be added to the roadway prism for widening of the roadway. Our early experience with these walls, and the experiences of others, has indicated that current design procedures are conservative, especially for geosynthetic reinforced systems. We felt that if we could develop a more accurate procedure for estimating reinforcement loads in these walls, substantial cost savings for WSDOT (and nationally as well) could be obtained.

This has been a long-term research project, and the research is continuing. From this research, a new design method for the internal stability of MSE walls termed the K-Stiffness Method has been developed, as reported in previous Annual Reports. The new method appears to provide the ability to significantly reduce the amount of soil reinforcement required due to the greater accuracy and reliability of the method, with potential significant cost savings for these types of retaining walls. The work has been published in international journals and conferences, and is receiving praise worldwide as a major breakthrough for the design of these types of wall systems. We have begun implementation of the research completed thus far through construction and monitoring of some test walls on SR-18 that have been reported in the 2005 annual report. We have also provided step-by-step design procedures for this new method in the WSDOT GDM.

This research will continue through 2009 to extend this method to lower quality fill materials, improvements in seismic design, and improvements in the facing design model used in the K-Stiffness Method, opening the door to additional cost savings and improved design accuracy. Our efforts have recently been joined with similar Japanese efforts to implement the K-Stiffness Method in their own country, giving us access to their wall data, much of which is for lower quality fill materials. The results of this effort have been published in international journals. We will also continue to work with the AASHTO Bridge Subcommittee to incorporate the K-Stiffness method in the AASHTO LRFD design specifications, a very important research implementation step.

Electronic Preservation of Geotechnical Design and Construction Files

The paper files that contain geotechnical subsurface data, design, and construction records is in effect a significant and important database of geotechnical information that has cost millions of dollars to produce over the years. This information is used routinely for geotechnical design of projects both by in-house staff and consultants and is a very valuable resource. The preservation of these files electronically is strategic for the department both to protect this significant investment and make access to this information easier for those involved in geotechnical design as well as related fields. The database structure, and the detailed procedures for file organization and the scanning/recording process were developed in 2006. Staff to do this work have been hired, and the scanning equipment has been obtained. Preparation of the files for scanning and the actual scanning of the project files has begun as of January 2007. This work has continued throughout 2007.

Pit and Quarry Development Pilot Program

Beginning in the 2007-2009 biennium $100,000 was allocated for a pilot project to identify marginal materials and to identify new sources of better materials for Regions that have state-owned pits and quarries. The focus of this pilot effort was the NE corner of the state and aggregates for HMA, specifically selecting Pend Oreille County in the Eastern Region as the first area to investigate.

During this first year of the project a GIS map for Pend Oreille County was prepared that included locations of the P&Q sites. Geology for the county was added that identified the geologic units for the P&Q sites. All Materials Laboratory testing data for the P&Q sites were scanned, and a table with test results is being developed. A field review of 13 aggregate sites was conducted, and selected geologic units were sampled for laboratory testing. Based on the field review and test results, it was concluded not to pursue alluvial/glacial aggregate pit sites within the valley bottom. These sources tested poorly, were fine-grained with many existing sources depleted. The focus will be on the bedrock sources that tested well, and include USFS quarry sites. A review of the USFS test data in Colville was completed. These data include geologic reports for specific quarries located in the Colville National Forest.

Developing GIS as a Geotechnical Design Tool

The Division began using Geographic Information Systems (GIS) technology and hired a GIS Specialist in October 2006. Since then, GIS has been used extensively to provide mapping, analysis and data management support on geotechnical engineering design projects. GIS supports Division daily operations and contributes to achievement of Materials Laboratory strategic objectives by supporting projects such as Pits and Quarries. This year the Division increased its GIS capabilities with the addition of a new GIS Support Staff position. This was a very productive year in terms of developing a comprehensive understanding of the complex GIS needs of the Division. GIS was instrumental in supporting a variety of projects including: estimation of cable mesh drapery requirements, landslide and debris flow analyses, highway alignment assessments, 3D viewshed analysis, aggregate resource quality mapping, subsurface geologic mapping, borehole navigation mapping, analysis of unstable slopes and analysis of bridge vulnerability to seismic and liquefaction hazards.

The Geotechnical Workbench project to develop spatial data and tools to support GIS mapping and analysis is nearing completion, and will be deployed in early 2008. Standards for data collection and management are also being developed to improve the integrity and availability of geotechnical data and documentation in the future.

A Scope of Work has been developed to support the development of a Geotechnical Database Management System (GDBMS) what will improve the management of geotechnical data and data delivery. The GDBMS establishes strategies for managing geotechnical data, and a key feature will be the ability to spatially locate geotechnical boring logs.

A Scope of Work has been developed to create an application using ArcGIS Server technology to link geotechnical project documents stores in a Stellent ™ database with spatial features in a web-based GIS environment.

Develop Seismic Bridge Foundation Program Needs

The current seismic retrofit program that is part of the P2 program does not really address bridge foundation stabilization needs resulting from liquefaction. This issue not only affects the seismic

retrofit program, but also has implications regarding how to address liquefaction stability concerns when widening an existing bridge for capacity or alignment improvements. In 2006, a section was added to the GDM that addresses the process and design standards to use when a bridge needs to be widened and the existing bridge has not been previously stabilized for liquefaction. While that process had been carried out informally in past years to address this issue, and the process defined in the GDM for this issue was used in a few instances in 2007, the process itself could not be effectively implemented. Therefore, the need to stabilize existing bridges when doing widenings has had a programmatic impact. Additional funding will be required to address the programmatic impact of this issue.

Therefore, efforts to formulate a strategy were made to programmatically address the liquefaction issue with respect to existing bridges. These efforts included participation by the Bridge Office, Program Management, upper management, as well as the Geotechnical Division. A liquefaction folio and presentation were developed to begin educating decision makers and region staff regarding the liquefaction issue and its impact. A statewide map was created using GIS technology and a liquefaction susceptibility map developed by the Department of Natural Resources (DNR) to help identify which bridges are likely to be vulnerable to liquefaction stability problems to help quantify the problem. Conceptual level liquefaction assessments were conducted for some of the bridges on key corridors including SR-167, SR-5, SR-90, and SR-405. Geotechnical design strategies to assess liquefaction impacts more accurately were conceptually formulated (in the hope of reducing the impact), and plans were made to try out these new design strategies on a few projects (e.g., SR-529 Ebey Slough Bridge, Bridge 167/112W at the SR-18 interchange). These new design strategies included specialized dynamic soil testing, complex effective stress analyses to assess site specific ground response, and other input parameters needed to assess the effect of the liquefaction on the response of the structure.

Proposed Programmatic Accomplishments for 2008

LRFD Design Specification Implementation for Foundations and Walls

Continued development of the AASHTO LRFD Bridge Design Specifications regarding foundation and wall design is anticipated in 2006. Specifically, we anticipate developing new load and resistance factors for anchored walls, new design specifications for micro-piles, new design specifications for soil nail walls, continued refinement of shaft foundation resistance factors, and development of new resistance factors for service limit state design of foundations (i.e., settlement, lateral deformation).

MSE Retaining Wall Research

The research on MSE walls will continue through 2009, providing refinement of the K-Stiffness Method, and broadening its applicability to poorer quality backfill materials as high quality backfill materials continue to become more scarce, and also integrating it with other aspects of MSE wall design (e.g., seismic design, abutment loads, etc.). Regarding the use of poorer quality, and therefore less expensive, wall backfill materials, we will continue our efforts to combine efforts with a major NCHRP study (which a member of the Geotechnical Division happens to be chairing) on the same subject to develop definitive guidance that would allow use of lower cost backfill materials for this application. We will also be combining our efforts with the Japanese to incorporate their wall data using lower quality fill materials with our own efforts. Furthermore, we anticipate completing the analysis WSDOT's first retaining walls designed with

the new method (on SR-18), and will use the information (e.g., strain and deformation measurements) gathered on the performance of the proposed field test walls to continue to improve the method. We also hope to line up other state DOT's for building full scale field walls during 2007 using the new method and monitoring their performance using instrumentation. These field design method verification walls are critical to the implementation of this research, as well as the extension of this new method to poorer quality soils and other loading situations such as seismic. Though several state DOT's have indicated an interest in doing test walls to help with K-Stiffness Method implementation, we have yet to see a test wall under contract other than the ones WSDOT already has done on SR-18. We will also continue to work with the AASHTO Bridge Subcommittee to continue the implementation process for this new design method in the AASHTO LRFD design specifications.

Developing GIS as a Geotechnical Design Tool

With the deployment of the Geotechnical Workbench, the development of the GDBMS, and development of web-based and desktop GIS applications this year will be exciting. Now that the scope of work for developing a statewide GIS database of boring logs has been developed, it is anticipated that the Division will begin populating the boring log database in the coming year. The Geotechnical Division will also utilize a balanced combination of web-based applications (e.g., ArcGIS Server and ArcIMS), desktop applications (e.g., ArcGIS Desktop and ArcGIS Explorer), and database technology (e.g., SQL and StellentTM) to meet the increased demand for GIS products and services in 2008. GIS will undoubtedly be used for increasingly more complex and sophisticated analysis projects, as well as the development of new products and services. Continued participation in the GIS Advisory Committee, the driving force behind the implementation of GIS throughout the agency, will further establish the Division's position as a key player in the decision making process and allow the Division to influence policies that affect the implementation of GIS at WSDOT.

Update WSDOT Geotechnical Design Manual (GDM)

It is recognized that the GDM needs to remain a living document to keep up to date with the latest developments, but that changes to the manual should not be made frequently. Our goal is to update the manual once per year, unless an urgent need is discovered that warrants correcting sooner. Furthermore, some chapters in the GDM were not fully developed. One of the key updates to the GDM being prepared at this time is to Chapter 6 (seismic design). In 2006, the AASHTO Bridge Subcommittee passed the first major update to the seismic design provisions for bridges and other structures since 1983.

Pit and Quarry Development Pilot Program

This upcoming year will target the sampling and testing of potential bedrock sources, with a focus on specific geologic rock types that have a high potential to produce high quality quarry sources. The information obtained from the USFS will be used to review the quarry sites in the Colville National Forest. A project report with results and recommendations will include aggregate resource maps for the targeted field area. We will work with the Eastern Region Material Engineers Office to plan a strategy for new source investigations and beneficial development of current materials sources.

Pavement Management Performance Measure

Pavement Management Section

Pavement Condition Trend

This performance measure documents the statewide pavement condition as represented by the pavement structural condition (cracking, faulting, patching, etc.), rutting and ride (smoothness) measurements on the state highway network. This measure includes all pavement types, chip seal, asphalt, and concrete. These condition measures are used to characterize each pavement section in to one of five categories: very good, good, fair, poor, and very poor. A pavement section is determined to be "due" for rehabilitation when it has reached the "Fair" category based on one or more condition measures. The chart illustrates the number of lane miles of pavement in each of the five categories from 1995 to 2006 for the approximately 17,500 lanes miles of state route system. WSDOT's goal is to reach approximately 1,700 lane miles of pavement in the "Fair" category and none[1] in the "Poor" or "Very Poor" category. Since last reporting in January 2007, the 2006 condition data (rated and analyzed during 2006-2007) has been added and shows that the poor pavement ("Poor" and "Very Poor" categories) has decreased by about 9 lane miles or 0.8 %.

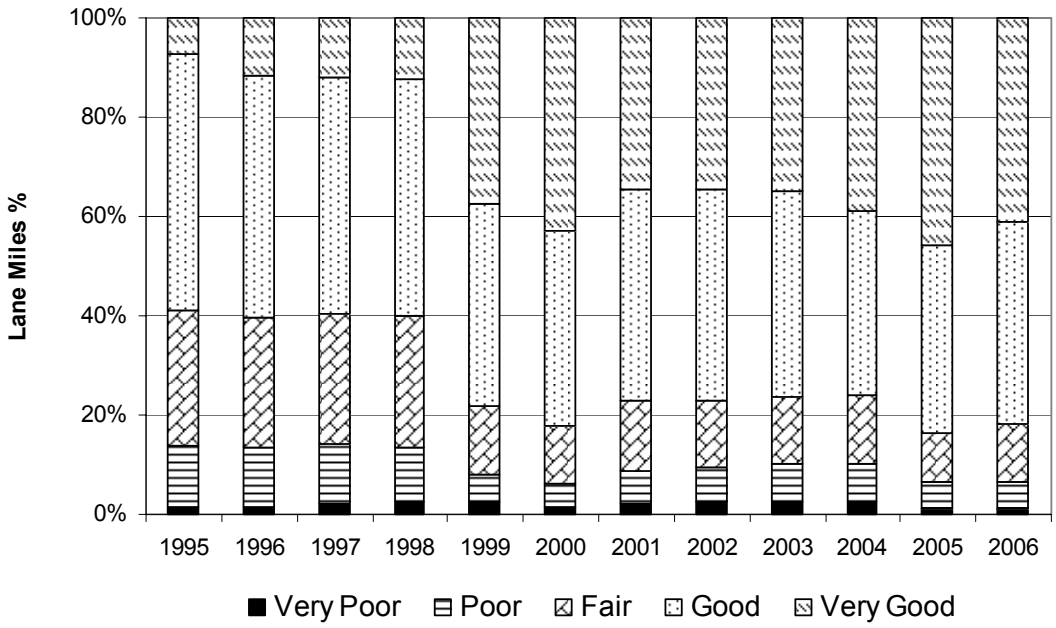


Figure 1: Pavement Condition

The following table represents the above figure and illustrates the number of good (pavements in very good, good and fair condition) and poor (pavements in poor and very poor condition) lane miles for all pavement types.

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Good (lane miles)	15314	15344	15197	15383	16354	16516	16186	16197	15916	15965	16617	16743
Poor (lane miles)	2426	2368	2515	2387	1441	1068	1578	1659	1787	1797	1162	1153

[1] Except for those sections of pavements that are intentionally delayed due to upcoming reconstruction or other major construction work.

QA/QC in Pavement Rating

This performance measure attempts to quantify the accuracy of annual pavement condition survey using statistical methods. One of the concerns WSPMS users have raised in the past has been that, in some cases, the survey results do not accurately reflect the condition of the pavement section. After the rating crew has finished rating a "set" (approximately 100 miles of roadway), about five random sample sections, each approximately 1 mile long, are selected within this set and are rated again ("sample" rating) by a different rater than the one who performed the "production" rating. The Pavement Structural Condition (PSC), a combined index of the various distresses on the pavement surface, is then computed using both the "production" rating and the "sample" rating and are then compared for any statistical differences. For the 2006-2007 pavement rating, 505 sample sections (each approximately 1 mile long) out of a total of approximately 8,500 miles of rated roadway were considered. The "production" and "sample" ratings were tested for differences using paired t-test and Wilcoxon signed rank test and both tests indicated that there are no significant differences between the two ratings.

The following two figures show graphically the differences between the "production" and "sample" rating. Out of the 505 sample sections considered, 500 sections (99%) had a PSC difference of less than 10 points and 5 sections (1%) had a PSC difference of more 10 than points. In Figure 2, the solid line represents the line of equality (R-squared = 93.3%) and the dashed lines represent ±10 PSC points difference.

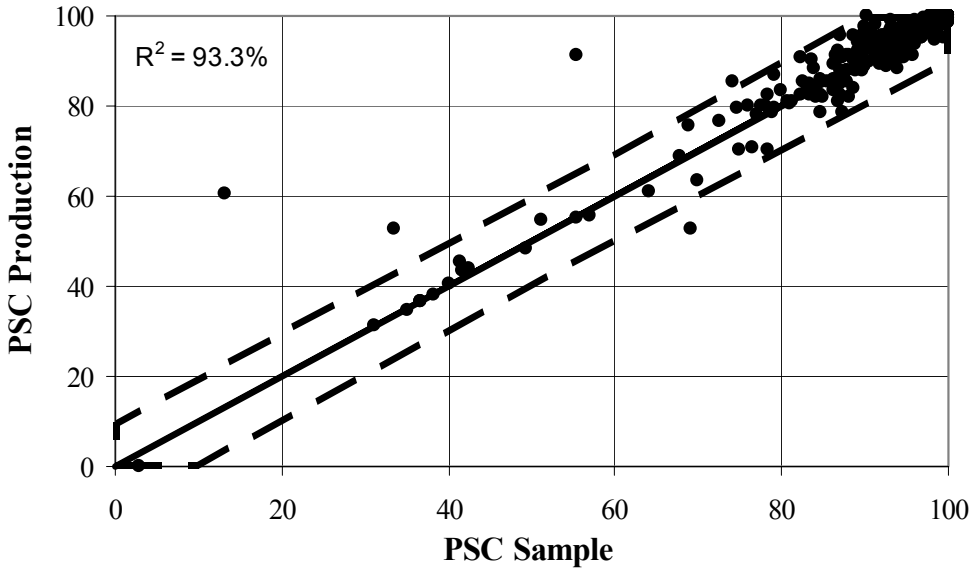


Figure 2: PSC Comparison

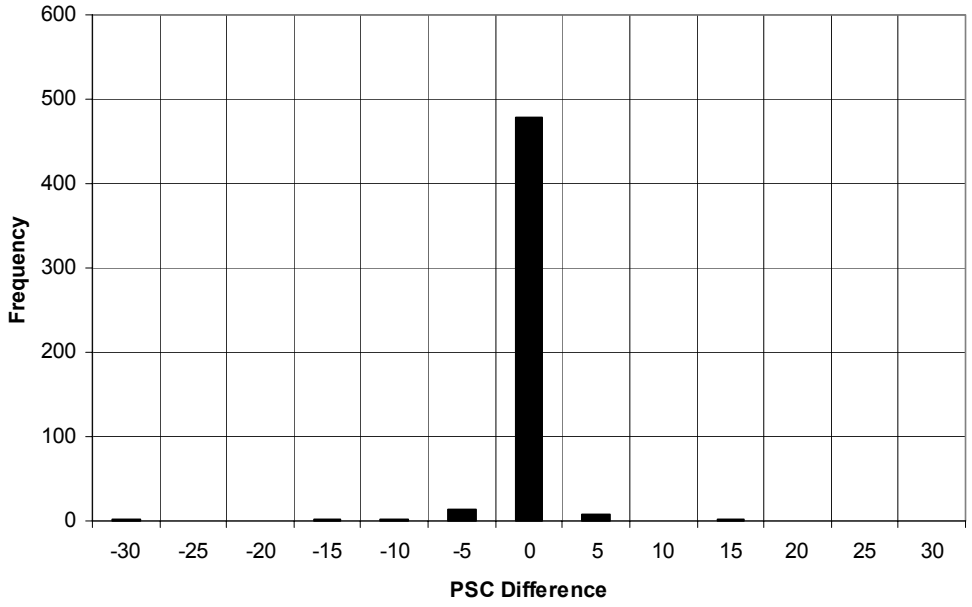


Figure 3: Histogram of Differences in PSC between Production and Sample Rating

Pavement Design

Pavements –Review of Region Pavement Rehabilitation Reports

This performance measure documents the number of days to review, analyze, and concur with Region Rehabilitation Reports. This measure accounts for the time the Region Rehabilitation Report is received at the Headquarters Materials Laboratory until the time that the concurrence letter is completed and sent to the Region. The target for rehabilitation report concurrence is 20 days. Twenty days was set as a target for 2006 and again in 2007. The average time required to review rehabilitation reports for 2006 was 7 days. The average time required to review rehabilitation reports for 2007 was 3 days. On occasion, the target of 20 days was exceeded, however, this was often the result of obtaining addition information from the Region or other data needed to review the reports.

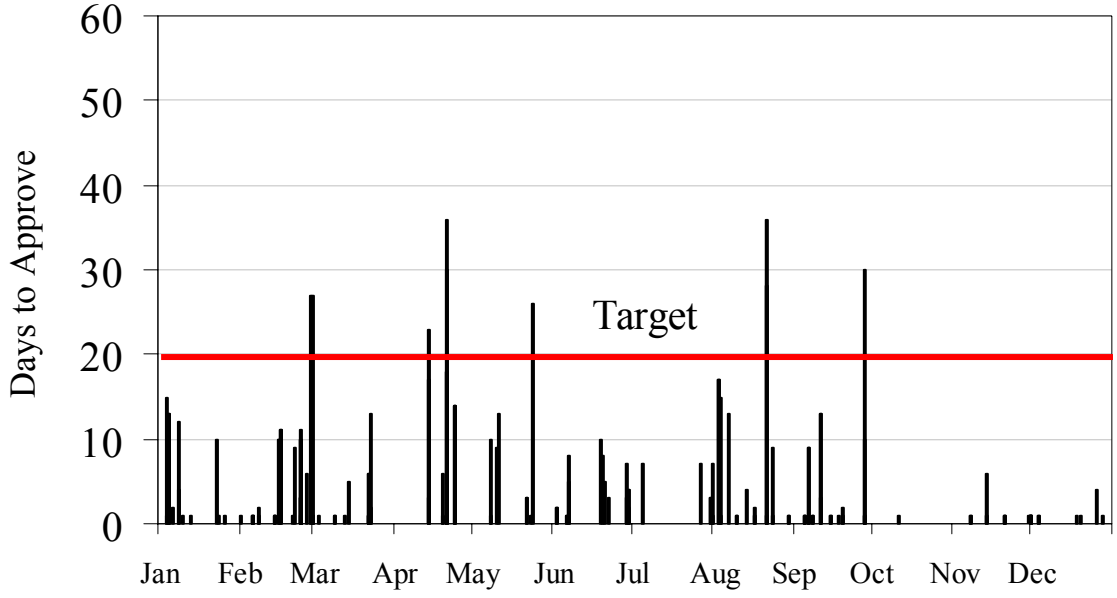


Figure 1. Days Required to Review Pavement Rehabilitation Reports for 2006.

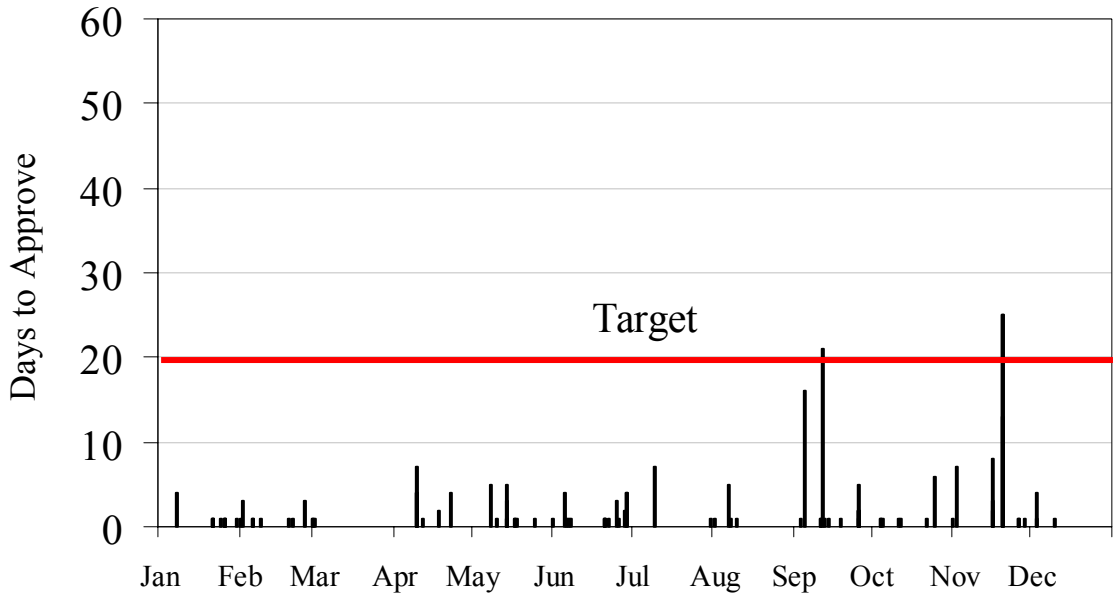


Figure 2. Days Required to Review Pavement Rehabilitation Reports for 2007.

Administrative Performance Measures

Information Technology Support Performance Measure

IT Support – Help Desk Response Time

The Materials Laboratory IT Support categorize requests according to the following five major areas: Workstation (hardware, software, etc); Printing (copier, printer, label maker, etc.); Network (hardware, software, etc.); Services (data backup, internet or intranet, loaner, research and development, etc.); Account Services (domain, e-mail, RAS, etc.).

The following graphs illustrate the average completion time for all IT help requests in the five mentioned categories. Categories, such as development, are not included in this performance measure since the Materials Laboratory IT Support does not have direct control over this function. In addition, the analysis has excluded all requests that require the acquisition of either hardware or software, since in many cases this may require several days to several weeks for the acquisition and shipment.

Total Requests in 2007 – 3894